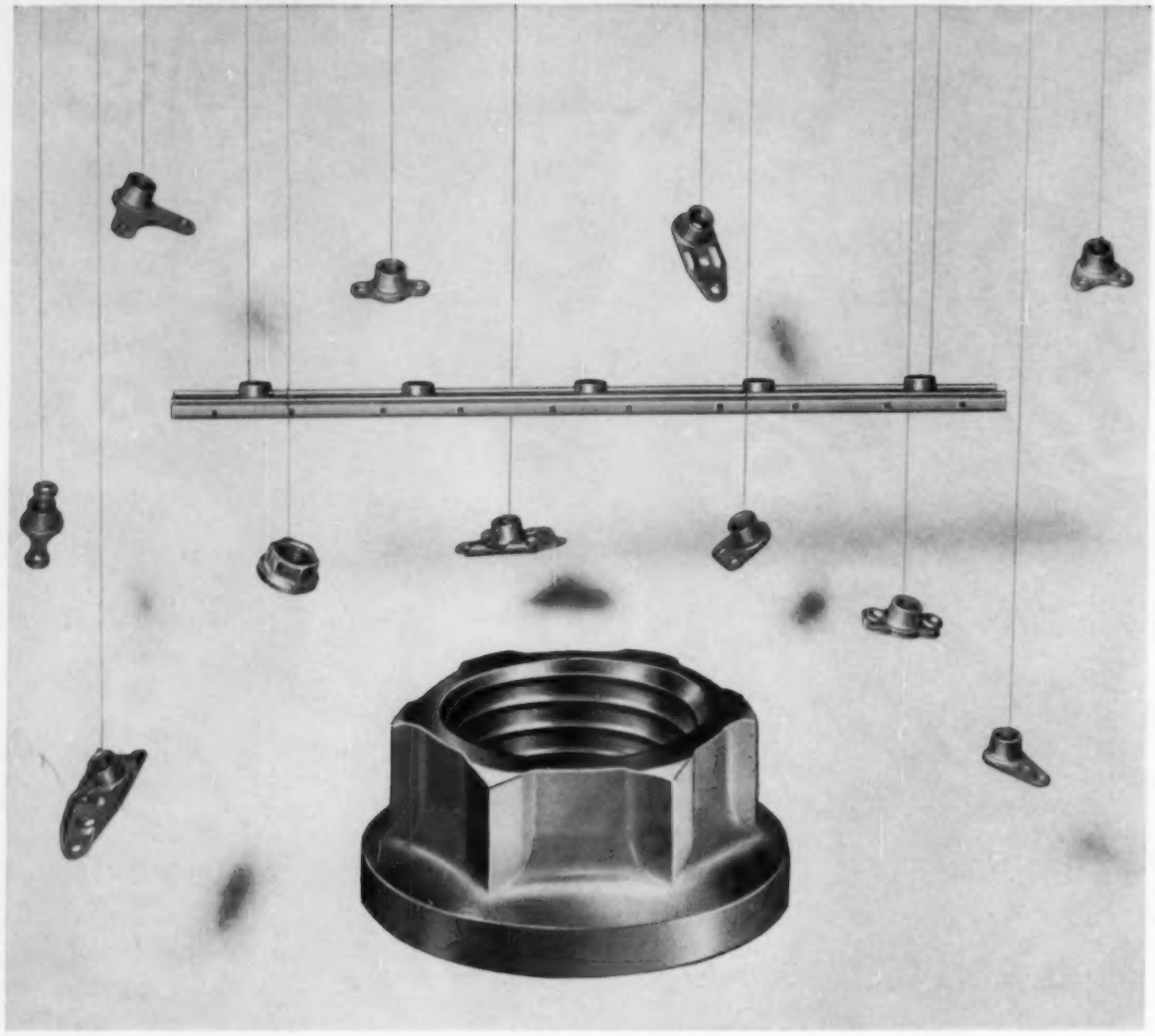
Aviation Week

Including **Space Technology**

March 2, 1959

Nationwide Weather Radar System Planned

McDonnell 119 Turbojet Utility Aircraft



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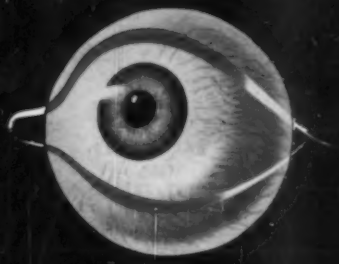

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AVIATION CALENDAR

March 9-12—Aviation Division Conference, American Society of Mechanical Engineers, Statler-Hilton Hotel, Los Angeles.

March 10-11—Third Annual Shock Tube Symposium, Old Point Comfort, Ft. Monroe, Va. For details: Armed Forces Special Weapons Center, Kirtland AFB, Albuquerque, N. M. Attn.: SWRS R. R. Birnkoff.

March 12—Symposium on Microwave Techniques for Computing Systems, Department of Interior Auditorium, Washington, D. C. Sponsor: Information Systems Branch, Office of Naval Research.

March 16-17—Conference on the Nuclear Optical Model, Florida State University, Tallahassee, Fla. Sponsors: National Science Foundation, Office of Naval Research, Air Force Office of Scientific Research/Nuclear Physics Division. (Publication of proceedings is anticipated.)

March 16-17—Spring Conference, Lubrication Division, American Society of Mechanical Engineers, Franklin Institute, Philadelphia, Pa.

March 16-20—11th Western Metal Exposition and Congress, American Society for Metals, Pan Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif.

March 23-25—Flight Testing Conference, American Rocket Society, Daytona Plaza Hotel, Daytona Beach, Fla.

March 23-26—National Convention, Institute of Radio Engineers, Coliseum and Waldorf-Astoria Hotel, New York, N. Y.

March 25-27—16th Annual Conference, Pacific Coast Section of the Society of the Plastics Industry, Hotel del Coronado, San Diego, Calif.

March 31-Apr. 3—National Aeronautic Meeting, Society of Automotive Engineers, Hotel Commodore, New York, N. Y.

Apr. 2-3—Conference on Electrically Exploded Wires, sponsored by the Thermal

(*Continued on page 6*)

AVIATION WEEK Including Space Technology

March 2, 1959

Vol. 70, No. 9

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AVIATION CALENDAR

(*Continued from page 5*)

Radiation Laboratory of the Geophysics Research Directorate of the Air Force, Cambridge Research Center, Somerset Hotel, Boston, Mass.

Apr. 5-10—1959 Nuclear Congress, Municipal Auditorium, Cleveland, Ohio. For information: Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

Apr. 6-8—Fifth National Military-Industrial Conference, Palmer House, Chicago, Ill.

Apr. 8—Aviators' Post No. 743 Gen. William Mitchell Award Dinner, Waldorf-Astoria, New York, N. Y.

Apr. 12-15—Annual Meeting, American Assn. of Airport Executives, Savannah, Ga.

Apr. 12-16—International Conference on Fracture, Massachusetts Institute of Technology, Cambridge, Mass. Sponsors: Air Force Office of Scientific Research/Solid State Sciences Division, Office of Naval Research, National Science Foundation, National Academy of Sciences/NRC. (Contact: Dr. David K. Felback, National Academy of Sciences, Washington, D. C.)

Apr. 12-19—Air Force Assn.'s World Congress of Flight, Las Vegas, Nev.

Apr. 16—Conference on Aviation Safety, Hotel Statler, New York, N. Y. Sponsor: Greater New York Safety Council.

Apr. 16-17—17th Annual Meeting, Aeronautical Training Society, Desert Inn, Las Vegas, Nev.

Apr. 16-18—11th Annual Southwestern Institute of Radio Engineers Conference and Electronics Show, Dallas Memorial Auditorium, Dallas, Tex.

Apr. 21-22—Spring Technical Conference on Electronic Data Processing, Cincinnati Section of the Institute of Radio Engineers, Engineering Society Bldg., Cincinnati, Ohio.

Apr. 21-23—Ninth Annual Convention, International Airline Navigators Council, Hotel Manhattan, New York, N. Y.

Apr. 22-24—1959 Annual Meeting, Institute of Environmental Engineers, LaSalle Hotel, Chicago, Ill.

Apr. 23-24—Quarterly Regional Meeting, Assn. of Local and Territorial Airlines, Bel Air Motor Hotel, St. Louis, Mo.

Apr. 30-May 1—Controllable Satellites Conference, American Rocket Society, Massachusetts Institute of Technology, Cambridge, Mass.

May 4-6—National Aeronautical Electronic Conference, Institute of Radio Engineers, Biltmore Hotel, Dayton, Ohio.

May 4-7—Fifth Annual Flight Test Instrumentation Symposium, sponsored by the Instrument Society of America, Seattle Section, Olympic Hotel, Seattle, Wash.

May 6-8—Seventh Regional Conference and Trade Show, Institute of Radio Engineers, University of New Mexico, Albuquerque.

May 6-8—1959 Electronic Components Conference, Benjamin Franklin Hotel Philadelphia, Pa. Sponsors: Institute of Radio Engineers, Electronic Industries Assn., American Institute of Electrical Engineers, West Coast Electronic Manufacturers Assn.

May 6-9—15th Annual National Forum, American Helicopter Society, Sheraton Park Hotel, Washington, D. C.

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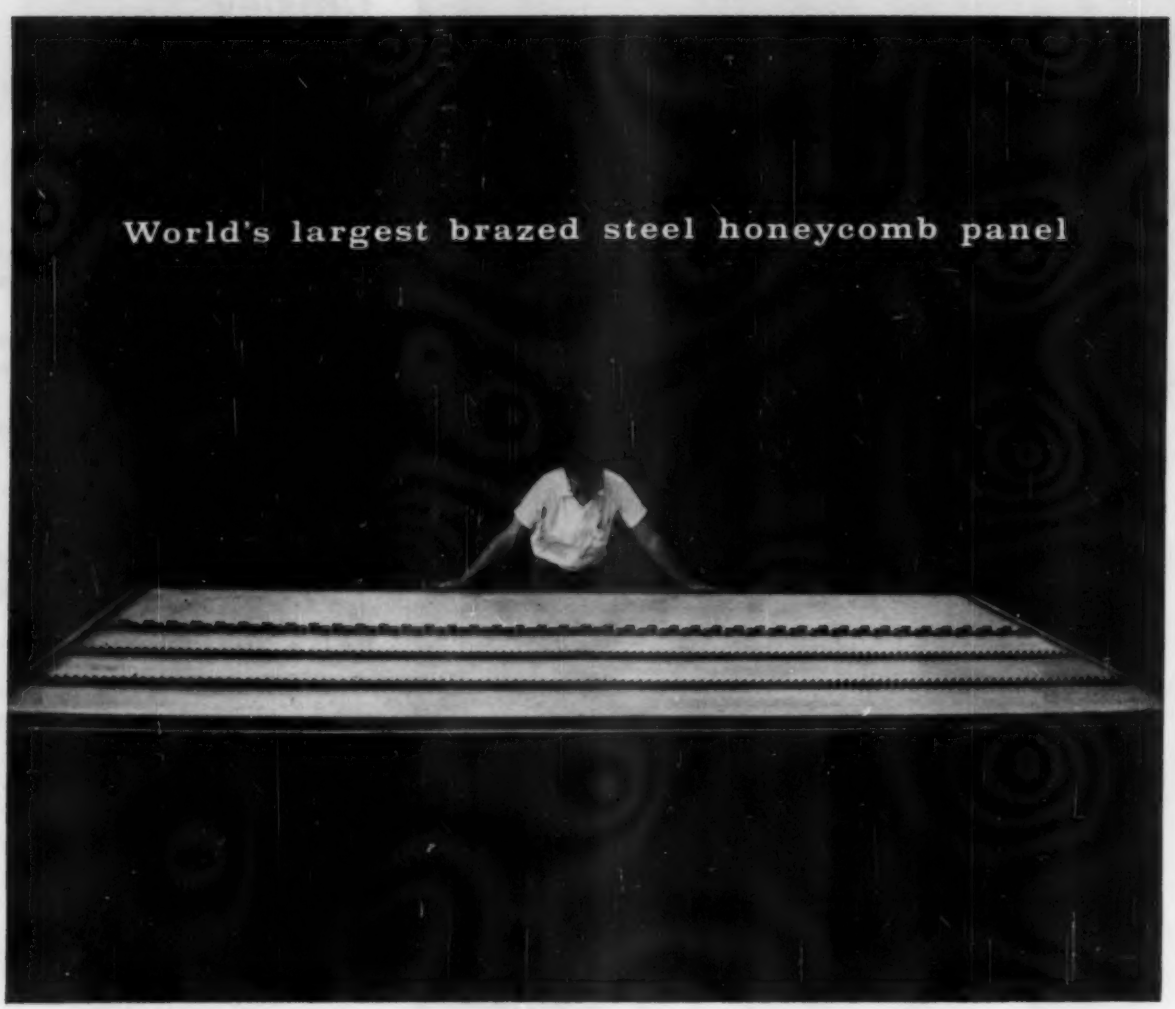

Produced by Rohr to test manufacturing feasibility, this 6 by 12 foot panel represents a giant stride toward meeting the structural demands of modern flight.

A variety of structural inserts and external fittings, such as might be required in actual production units, have been incorporated.

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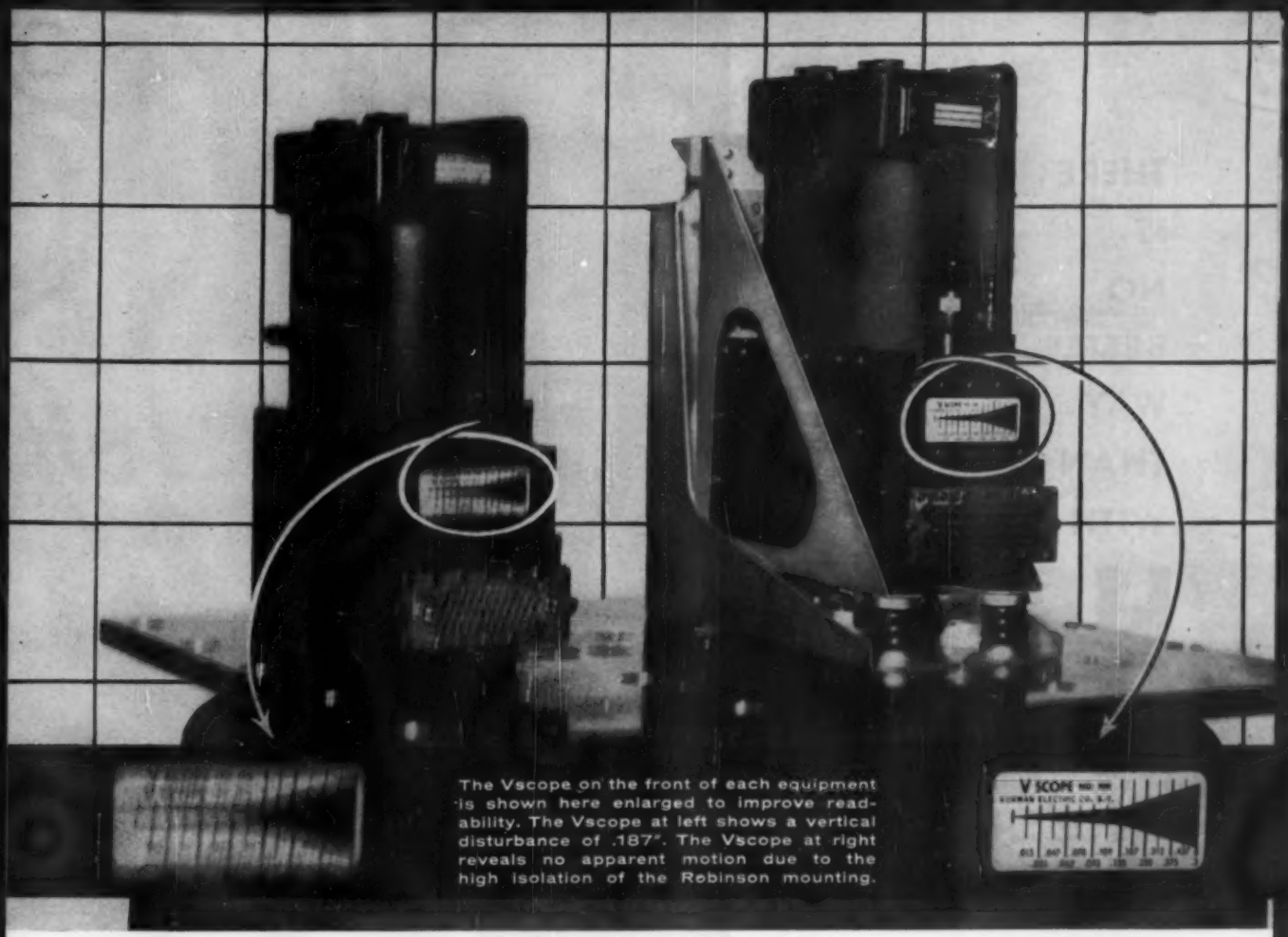

The Vscope on the front of each equipment is shown here enlarged to improve readability. The Vscope at left shows a vertical disturbance of .187". The Vscope at right reveals no apparent motion due to the high isolation of the Robinson mounting.

12.0 "G" reduced to 0.6 "G"

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Look at the above illustration, showing two Bendix air data sensors on an electromagnetic shake table. Notice the left hand unit which is mounted solidly to the oscillating head of the shaker. The image is blurred because a vibratory input of about .187" double amplitude at 35 c.p.s., equalling an acceleration force of 12 "g's", is being applied directly to it.

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Because of the proven performance and reliability record of airborne components *now* protected by Robinson mountings, an increasing number of manufacturers in the electronics industry are incorporating Robinson mountings as an *integral part* of their basic equipment design.

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ARPA Seeks 1970-80 Missile Defenses 18
▶ Anti-gravity, anti-matter, radiation weapon concepts to be studied in search for long term solutions.

F-27s Boost West Coast Revenue Miles 28
▶ In first three months' operation turboprop aircraft increase revenue miles flown; draw new customers.

U. S. Planning Nationwide Weather Radar Network . 56
▶ System, which would integrate existing and proposed facilities, is expected to be in operation within next 10 years.

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COVER: Turbojet engine pods on McDonnell 119 utility jet transport will be somewhat smaller on production model, which will be powered by Pratt & Whitney JT12 engines. Prototype 119, now in flight test phase (AW Feb. 23, p. 38), is powered by four Westinghouse J34s. Aircraft is contender in U. S. Air Force UCX competition.

PICTURE CREDITS

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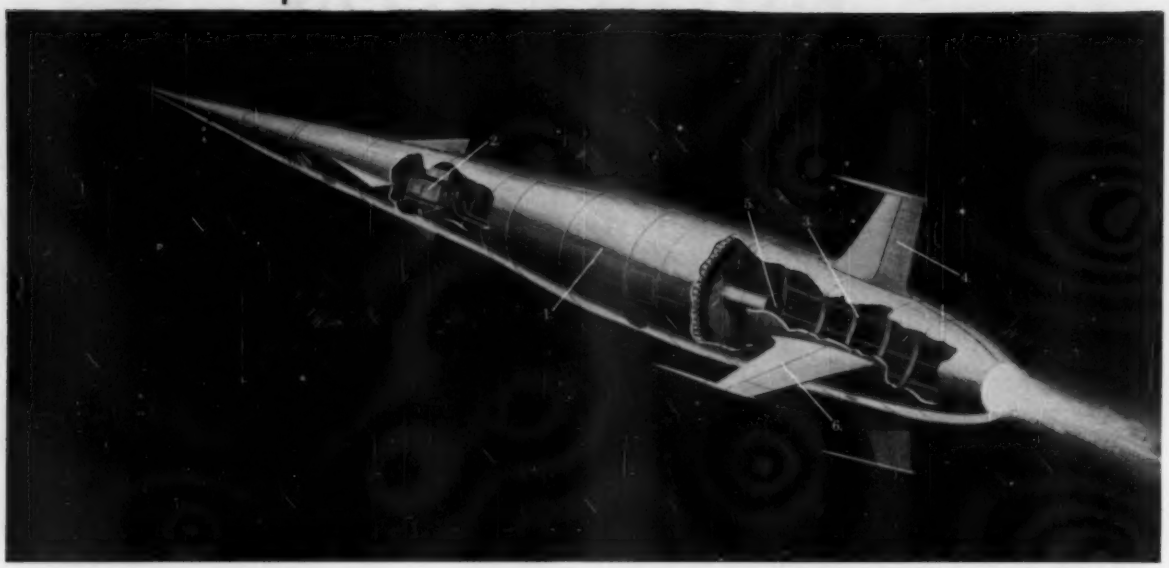

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5. **ROUND EXTRUDED TUBING** for integral body sections.
6. **SHEET** for external skins of fins, rudders and wings.

THERMAL PROPERTIES OF LIGHTWEIGHT MAGNESIUM

offer advantages to missile men

Most engineers are aware of the advantages available to them when they combine magnesium's light weight with its good mechanical properties at elevated temperatures up to 800°F. There are, however, other advantages such as thermal properties that are less well known. They, too, can be of real value to missile designers. In many cases they will open new areas in design previously considered closed to magnesium.

Let's consider one of these, magnesium's high specific heat and its relationship to missiles. This can mean lower temperatures for given flight conditions. As a result magnesium can be used under very severe flight conditions for short time applications. (See Fig. 2.) This permits the use of magnesium in high speed missiles which are exposed to heat generating atmosphere for only a matter of a few seconds. With magnesium acting as a heat sink it can result in reducing environmental temperature for electronic instruments.

Magnesium offers other thermal properties that are of value in aircraft and missile design. For example, the thermal diffusivity of magnesium-thorium alloys $\left\{\frac{\text{Thermal conductivity}}{\text{Specific heat x density}}\right\}$ is high and remains fairly constant over a large temperature spread. Between 68° and 900°F. the thermal diffusivity of these alloys is in the range of 0.57 and 0.75 cm.²/sec. (2.2 and 2.9 ft.²/hr.)

For more complete data send for Bulletin 141-187 "Magnesium Alloys for Elevated Temperature Use." Contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department 1300X3-2.

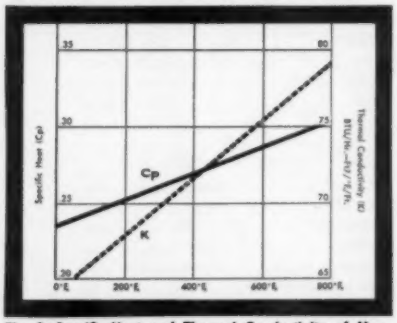

Fig. 1. Specific Heat and Thermal Conductivity of Magnesium-Thorium alloys.

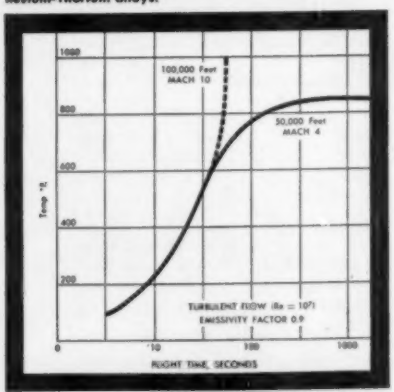

Fig. 2. Effect of Structure Temperature and Flight Time on Mg-Th Sheet Alloys at Mach 4 and 50,000 Feet and Mach 10 and 100,000 Feet.

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EDITORIAL

The Case for Nuclear Powered Aircraft

Public hearings on the nuclear powered aircraft program will begin soon on Capitol Hill thanks to the persistent proddings of Sen. Clinton Anderson and Rep. Melvin Price of the Joint Congressional Committee on Atomic Energy. This will be the first opportunity for the American public to get any reasonably clear picture of the status of our military nuclear powered aircraft progress and the real reasons why this progress has reached a point of virtual stagnation.

Until now, this program, with some genuine cause, has been heavily shrouded in secrecy. Only its opponents have been able to make public statements supporting their secret decisions to retard or eliminate its financial support. We are all familiar with the ""shitepoke" jibe of former Defense Secretary Charles Wilson when he tried to wipe out the entire program in 1953 and the more recent and technically indefensible statement of President Eisenhower that a nuclear powered aircraft, even if successful, "could only fly a few hundred feet off the ground" (AW Dec. 15, p. 27). And, of course, the monotonous chant of Deputy Defense Secretary Donald Quarles with the leitmotif of technical timidity and false economy is a key roadblock in any attempt to organize and sustain any type of fruitful program in this area. Mr. Quarles' consistent record of opposing any promising new technical development program proposed in the Pentagon during the past four years, including the initial USAF space exploration efforts, the radar network to monitor Soviet missile tests, the WS-117L reconnaissance satellite and efforts on basic research hardly lend credulity to his testimony against the nuclear powered aircraft program.

We firmly believe, along with congressional and USAF, Navy and industry experts who have testified on the program that there is a vital need for an accelerated development program aimed at producing militarily useful atomic powered aircraft. Within the limits of this space we will try to summarize the case for this type of program.

First, there is a definite military requirement for nuclear powered aircraft.

For the Navy, a large nuclear powered aircraft with subsonic cruise speeds would make an ideal anti-submarine warfare weapon. Equipped with new and far-ranging detection devices now under development, a relatively small fleet of these aircraft could effectively comb critical expanses of ocean rapidly and effectively to locate enemy submarines and keep them under constant surveillance, even those using nuclear power. For the 40 kt. speed of a nuclear powered submarine would avail little against the 350 kt. cruise speed of a nuclear powered ASW plane. The Navy believes it can best utilize an airborne nuclear reactor to drive turboprop engines with a closed cycle type of operation. For only a few million dollars it could take the first vital step toward developing this aircraft using the British Princess flying boat hulls now in mothballs at Cowes.

For the Air Force, a nuclear powered aircraft would serve several useful purposes. It would provide a vital new element of flexibility and dispersal to our strategic deterrent capability that would be militarily more effective and economically more feasible than current airborne alert plans with chemically fueled bombers.

A relatively small fleet of nuclear-powered bombers could remain on airborne alert continuously for periods of up to 30 days. They would require relatively short periods on the ground for maintenance and crew changes between missions. The entire fleet could be operated from a very few isolated island bases in the Atlantic and Pacific. These aircraft could carry heavy loads of long-range detection gear to provide a mobile flexible warning coverage beyond the capability of the fixed, immobile stations of the DEW Line and BMEWS that are so vulnerable to enemy ballistic missile attack.

The nuclear aircraft could also carry a sizable load of solid-fueled air launched 1,500-mi. ballistic missiles that would provide an important, dispersed and quickly available element of our strategic deterrent.

In addition, the unlimited range of the nuclear powered aircraft makes it ideally suited for low level penetration to enemy targets under or around radar and missile defense systems. The high altitude nuclear explosions from Johnson Island during the Hardtack operations in 1958 marked the turning point for both offensive and defensive aerial delivery systems. The nuclear effects at high altitude are so widespread and devastating from heat and radiation that neither presently known aircraft structures nor nuclear offensive armament can remain useful when subject to its effect even at long range.

It is this capability for long range, devious, low level penetration, most probably through holes in an enemy's defense blasted by its own air launched missiles, that gives the nuclear powered bomber a capability utterly impossible for chemically powered aircraft even with aerial refueling.

The nuclear powered aircraft also fits into the military picture as a long-range, heavy cargo logistics support aircraft that could operate without refueling over intercontinental round trip ranges.

Second, the development of useful nuclear powered aircraft is technically feasible, and this feasibility has been demonstrated in an experimental environment.

The 13-year development program, starved for funds in its best years and almost choked lifeless by several economy-dictated decisions, has laid the basis for technical exploitation into workable hardware. If any doubts remain—and there are none among the technical personnel actually working on these projects—they will soon be dispelled by the public appearance of a Soviet nuclear powered aircraft whose existence was exclusively reported in AVIATION WEEK, Dec. 1 (p. 27). The public appearance of a nuclear aircraft during 1959 also was unequivocally promised by the official Soviet radio New Year's Day scientific broadcast. There are many difficult engineering problems, particularly in high temperatures metallurgy, between experimental feasibility demonstration of airborne nuclear power and production of useful operational hardware. But the latter goal will never be achieved unless we take the first steps with the determination to progress through increasingly better systems until the desired efficiency and reliability are achieved.

Third, radiological safety will permit operation of nuclear powered aircraft for military purposes, including exposure of aircraft crews and ground maintenance personnel and the civilian population at large.

Many horror stories have grown to credulity in the atmosphere of unnecessary military secrecy that has surrounded the radiological safety aspects of nuclear powered aircraft both in the air and on the ground. There is no good reason why the results of military and industry studies and tests in this area should remain secret any longer, and we hope Rep. Price's group will pry it loose in the public interest.

Our nuclear powered aircraft program has suffered severely during the past five years from financial starvation and constant shifts in goals and pace by people who have had only the briefest and most vague contact with, or understanding of, the genuine problems involved in this undertaking. At this late date in the history of our technological weapons development race with the Soviet Union, it is imperative that we organize a technically sound and militarily useful nuclear powered aircraft program. Then, we must sustain it through its inevitable development problems and occasional experimental failures and finally employ its eventual products usefully in the military pattern of the future that is essential to maintain our position of leadership for the free world.

—Robert Hotz

thanks to *automatic* xerography...

A. Z. Mellon, left, supervisor, reproduction department, at Westinghouse jet engine plant, Kansas City, and O. D. Lambirth, section engineer, examine a series of offset paper masters that emerge as a continuous roll at the rate of 20 feet a minute from the XeroX® Copyflo® 11 continuous printer, background. The Copyflo printer has cut Westinghouse's average cost of preparing a master from 40 to 8⅔ cents, and saved additional time and money in other paperwork duplicating applications.

Westinghouse of Kansas City Saves $35,000 yearly

A XeroX® Copyflo® 11 continuous printer—*automatic* xerography at its brilliant best—has reduced the cost of preparing offset paper masters by nearly 80%, and stepped up reproduction capacity 25 times at the Westinghouse jet engine plant, Kansas City.

In so doing the Copyflo printer is turning out clear, high-quality, paperwork reproduction at a faster rate than the division ever attained previously by any other method.

The Copyflo continuous printer is saving Westinghouse $35,000 yearly. Recent changes in plant operations that will permit greater utilization of the Copyflo printer are expected to double those savings.

Prior to its installation, the cost of preparing an offset paper master, for instance, was approximately 40 cents. Now it is 8⅔ cents.

Westinghouse previously could turn out only 200 masters a day. Recently, it prepared 617 *in one hour* on the Copyflo printer.

Reproduction work at the Aviation Gas Turbine Division in Kansas City consists largely of forms, sketches, engineering drawings, change notices, and specifications. An important part of the volume is the reproduction of operational lineups, of which 100,000 to 140,000 a month are turned out.

Of priceless worth to Westinghouse is the speed with which engineering-drawing changes now reach production lines. Changes are distributed sooner, thus saving tremendously in machining operations.

A Copyflo continuous printer is an automatic copying machine operating on the electrostatic principles of xerography to produce dry, positive prints or offset paper master ready for immediate use. The prints or masters—in enlarged, reduced, or the same size—emerge from the printer at the rate of 20 feet a minute on a 2,000-foot continuous roll 11 inches wide.

Wherever fast and economic copying of thousands of *different* documents is the need, look to the Copyflo continuous printer for the happy solution. For full details write HALOID XEROX INC., 59-98X Haloid Street, Rochester 3, New York. Branch offices in principal U.S. and Canadian cities.

HALOID XEROX®

WHO'S WHERE

In the Front Office

Thompson Ramo Wooldridge, Inc., has elected the following operating executives of TRW's Thompson Products divisions, Cleveland, Ohio, to vice presidencies: **Pierce T. Angell**, engineering manager, Tapco Group; **Robert E. Cummings**, manager, Thompson Products Valve Division; **William M. Jones**, manager, Thompson Products Commercial Electronics Group; **Carl L. Kahlert**, manager, Thompson Products Replacement Division.

Brig. Gen. John W. Carpenter, III, commander, Edwards Air Force Base Flight Test Center, Calif. Gen. Carpenter replaces Brig. Gen. Marcus Cooper now assigned to the Federal Aviation Agency.

D. F. Magarrell, a director, United Air Lines, Inc. Mr. Magarrell is senior vice president-transportation services.

William G. Reynolds and **Joseph H. McConnell**, executive vice presidents, Reynolds Metals Co., Richmond, Va.

James K. Dysart, vice president-marketing, Leach Corp., Compton, Calif.

Melvin L. Doelz, vice president-Western Division, and **Robert C. Mullaley**, assistant secretary, Collins Radio Co., Cedar Rapids, Iowa.

Howard Carson, vice president, Cadillac Gage Co., subsidiary of Ex-Cell-O Corp., Detroit, Mich. Mr. Carson is general manager—Costa Mesa, Calif., operations.

Louis R. Zimov, vice president-manufacturing, and **Dr. Leonard C. Maier, Jr.**, vice president-marketing-defense products, Crosley Division, Avco Manufacturing Corp., Cincinnati, Ohio.

Robert E. Achenbach, vice president, Flight Support, Inc., Metuchen, N. J.

Honors and Elections

Dr. John Mason, chief of preliminary design for The Garrett Corp.'s AiResearch Manufacturing Co., has been appointed to the National Aeronautics and Space Administration's Advisory Committee on Mechanical Power Plant Systems.

Harvey Riggs, president of International Electronic Research Corp., has been elected president of the Strategic Industries Assn., Los Angeles, Calif.

Frederick L. Holman, chief of engineering standards and procedures, Aircraft Division, Bell Aircraft Corp., has been appointed to the National Aircraft Standards Committee of the Aircraft Industries Assn.

Changes

R. J. Landberg, assistant to E. H. Heinemann, vice president-director combat aircraft systems engineering, Douglas Aircraft Co., Inc., Santa Monica, Calif.

G. W. Trichel, military advisor to the group vice president-defense and special products, Chrysler Corp., Detroit, Mich.

Richard E. Roberts, head of the newly formed Instrumentation and Communications organization of General Electric's Missile and Space Vehicle Department, Phila., Pa.

(*Continued on p. 85*)

INDUSTRY OBSERVER

► Escape systems tests for the National Aeronautics and Space Administration's Mercury Man-in-Space project already have begun under direction of Langley Research Center. Wind tunnel and landing systems tests began last October. NASA has awarded Thiokol, Inc., $110,000 for XM-19E1 rockets for escape system.

► Gyrodyne drone helicopter under evaluation by Navy for use aboard destroyers will be used primarily as a "kill" weapon against submarines. Navy will rely upon destroyer detection gear to find the submarines, then launch the drones carrying small torpedoes in an effort to compensate for the World War II destroyer's lack of speed in relation to that of a nuclear submarine. Designations of helicopters under evaluation are the single-engine DSN-1 and twin-engine DSN-2. Powerplants being used are modified Porsche automobile engines.

► Fourth bidder for Army's Mauler anti-aircraft weapon system (AW Feb. 9, p. 23) is The Martin Co. The four became final contenders since they originally had had Phase I study contracts for the system. Award is expected within the near future. Other three bidders are General Electric, Convair and Sperry.

► First three squadrons of Convair F-106 interceptors are scheduled to go into operational service late this spring or early summer at McGuire AFB, N. J.; Geiger AFB, near Spokane, Wash., and Andrews AFB, Md.

► Third site for the ballistic missile early warning system (BMEWS), which the U. S. Air Force would like to locate near Prestwick, Scotland, has become the subject of a diplomatic dispute between the U. S. State Department and the British Foreign Office. USAF believes the third site is necessary for maximum effectiveness of the missile detection system. The British consider the site a prime target in case of war and are reluctant to grant permission for its installation.

► Lithium, one of the lightest but most reactive metals, is not being overlooked by Air Force researchers as a possible structural material for future space vehicles. ARDC scientists have just established its tensile strength at 84 psi. And although metal is kept under oil to prevent it from bursting into flame, the feeling is that it might prove serviceable in the near vacuum of space.

► Bureau of Aeronautics has begun procurement of beryllium wire for use as a reinforcing element in new composite aircraft structural materials.

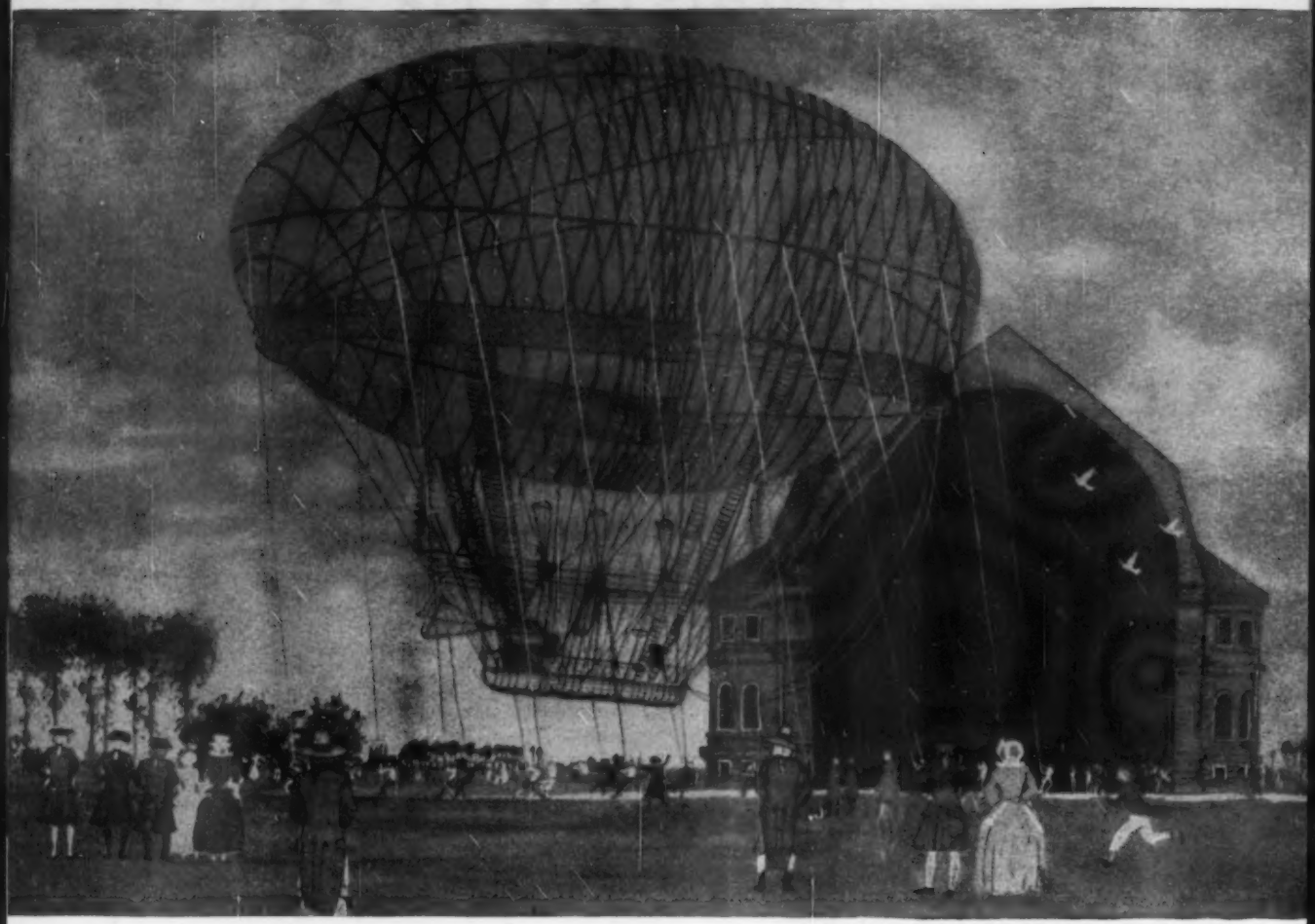
► Navy plans to incorporate some anti-submarine "kill" potential into its Polaris fleet ballistic missile submarines—probably the Subroc underwater-to-air-to-underwater long range weapon now being developed by Goodyear Aircraft Corp.—to avoid necessity of having to supply each system with accompanying killer submarines for protection.

► Communist China is flight testing another new aircraft—the "Yenan-1" built at the Northwest Polytechnical Institute. The single-engine monoplane has a top speed of 121 mph. and a ceiling of 11,480 ft. It can carry four to five passengers and also may be used for sports flying and agricultural work.

► Under present planning, Navy will eventually have a total of 51 ships equipped with either the Convair Terrier or Tartar surface-to-air guided missiles. Terrier ships will include five conventional-powered cruisers, a nuclear-powered cruiser and aircraft carrier, a nuclear-powered frigate, two Forrestal-class carriers, a destroyer and 19 frigates. Tartar ships will include three cruisers and 18 destroyers.

► De Havilland of Canada has increased the gross weight of the DHC-4 Caribou from 24,000 to 26,000 lb. to provide a greater payload and lengthened the cabin by 45 in. to accommodate an added row of seats which boosts passenger capacity of the aircraft to a total of 30.

Propulsion through the ages . . .

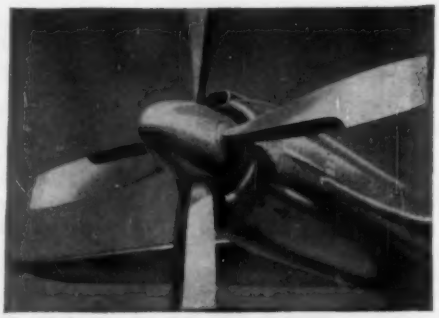


Propeller-driven airship designed by J. B. M. Meusnier, 1784

An astounding proposal : in 1784, just a year after the invention of the balloon, the Frenchman J. B. M. Meusnier conceived of an airship embodying the essentials of the modern dirigible. Beneath the gas bag hung a gondola control centre. There was a rudimentary rudder and three manually-operated propellers. A proper power plant was lacking, however, and perhaps that is why the dirigible remained a dream for another century. Aero designers of today are more fortunate. They *have* the proper power plants available, and have fitted propellers to them, creating turbo-jet power packages. The Rotol people, for example, designed, developed and produced the propellers for the first turbo-prop aircraft and now supply over 100 airlines and aircraft operators around the world who attest to Rotol reliability. Rotol turbo-props are standard equipment on the Vickers Viscount, Fairchild F-27, Grumman Gulfstream and Fairey Rotodyne.

ROTOL

The world's most experienced manufacturers of turbo-propellers — over 6,000,000 hours of flying time.



Rotol Incorporated after-sales service throughout the United States provides immediate spare parts delivery, technical service on propeller operations and applications.

For information on Rotol products and after-sales service, call J. Staples, President, Rotol Incorporated, 409 Jefferson Davis Highway, Arlington 2, Virginia. Phone OTis 4-6290

Washington Roundup

ARDC Shakeup

Watch for a major shakeup in Air Research and Development Command after the naming of a new commander to succeed Lt. Gen. Samuel Anderson who was recently nominated to command Air Materiel Command. Guiding lines for ARDC streamlining will be those outlined in the Stever report prepared by a special committee headed by Dr. Guyford Stever, former Air Force chief scientist and professor at Massachusetts Institute of Technology (AW July 14, p. 29). One of the biggest problems facing ARDC is reduction of its headquarters overhead and placing increasing emphasis upon exploratory research aimed at basic state of the art advances in critical areas.

New Bid for ABMA

Also look for the National Aeronautics and Space Administration to make another concerted attempt to absorb a portion of the Army's Ballistic Missile Agency at Huntsville, Ala. before the end of the year. In every appearance before the House and Senate space committees during the past few weeks, NASA administrator Keith Glennan has pointed to the feasibility of such a transfer. Glennan may have struck a responsive chord in Congress when he said NASA requires the capability to assemble and ground test space vehicles and to supervise subsequent launching operations. To build such an organization with the necessary facilities Glennan says, would require considerable funding while the transfer could be accomplished at relatively low cost.

However, Army resistance to such a transfer is not expected to diminish.

NASA Information Policy

In another area, professional staff members of both the House and Senate space committees are considering the possibility of an inquiry into the public information policies of the National Aeronautics and Space Administration. The act creating NASA directs the agency to provide the "widest practicable and appropriate dissemination of information concerning its activities and the results there." Complaints reaching staff members indicate that top officials seem reluctant to make public plans and programs of the agency.

Jet Surcharge Approved

International Air Transport Assn. traffic conference last week approved a jet surcharge on North Atlantic and South American routes to be effective April 1 as predicted by AVIATION WEEK last Oct. 27 (p. 26). Surcharge on first-class and de luxe seats on North Atlantic routes will be $20 while the surcharge for tourist and economy plan seats will be $15. On South American routes, the surcharge will be based on a progressive scale pattern according to mileage. For example, the surcharge on first-class and tourist flights between New York and Buenos Aires will be $20. No surcharges will be charged on jets operating in the Eastern Hemisphere. Pacific routes will be studied at a later date to determine whether a surcharge shall be adopted when jets are introduced on these routes. Cargo rates on certain commodities shipped over mid-North Atlantic routes were reduced about 30% below present rates.

Penalty Plan

Legislation setting penalties of up to a $10,000 fine and a year's imprisonment for participants in Civil Aeronautics Board cases who initiate off-the-record communications to CAB employes or members has been introduced by Rep. Oren Harris (D.-Ark.) as a follow-up of a study of the operations of regulatory agencies by House Commerce Committee which he heads (AW Jan. 12 p. 45).

Even if the intent is not secrecy, CAB members and employes would be required to place all communications in a public file. If the communication is oral or telephoned, a summary would be filed. Failure to file also would be subject to a penalty up to $10,000 fine and a year's imprisonment. Harris' measure also would:

- **Establish a detailed code of ethics** for Board members and employes.
- **Provide for selection of the chairman** and vice chairman by Board members, instead of by presidential designation.
- **Require that one Board member** prepare or personally direct the preparation of each Board decision. The member responsible would be identified in the decision.

Meanwhile, Harris is seeking a $200,000 appropriation to continue the investigation of CAB and other regulatory agencies by a Commerce subcommittee which he will head again this year.

In Congress

Meanwhile, in other Capitol Hill action:

- **Nuclear aircraft.** Rep. Albert Thomas (D.-Tex.) is urging Air Force to withdraw its nuclear aircraft project from General Electric Co. and place it with a new contractor. Thomas is chairman of the appropriations subcommittee which handles Atomic Energy Commission funds and was appointed to the Joint Congressional Committee on Atomic Energy this year. "The time element alone is enough to warrant a change," Thomas declared. "General Electric has been working on the project for eight or nine years. Sometimes when one man can't do the job, another man can." Rep. Melvin Price (D.-Ill.), chairman of the Joint Atomic Energy Committee's subcommittee on research and development, took direct issue with Thomas, saying: "I see no cause for complaint with the contractors on this project," he commented. "They have met every schedule that has been set, and the men working on the project are dedicated. If there has been a hold-back it is not because of the contractors."
- **Gas taxes.** Rep. Wilbur Mills (D.-Ark.), chairman of House Ways and Means Committee, is opposed to the President's proposal to increase the tax on aviation gas from 2 to 4.5 cents a gallon and also levy a 4.5 cent tax on jet fuel. Mills opposition means the measure has little chance of congressional approval. He is not yet committed on a levy of two cents a gallon on jet fuel, now tax free.
- **Radio frequencies.** House has voted the Commerce Committee $150,000 for a comprehensive study of the radio spectrum and policy on the award of frequencies. Airlines object to the arbitrary requisitioning of frequencies by government users. Air Transport Assn. and Aeronautical Radio, Inc., now have a court case pending against the FCC for withdrawal of frequencies needed for airline communications services from government use.

—Washington staff

ARPA Seeks 1970-80 Missile Defenses

Anti-gravity, anti-matter, radiation weapon concepts to be studied in search for long-term solutions.

By James A. Fusca

Washington—Countermeasures that are aimed at providing essentially complete defense of the United States against ballistic missiles in the approximate period between 1970 and 1980—including anti-gravity, anti-matter, and radiation weapons—will be investigated in a study program sponsored by the Advanced Research Projects Agency. Contracts will be let early next month.

Basically, the program is an attempt to break away from the present environment of engineering limitations in solutions to the ballistic missile defense problem, and to find better fundamental approaches to a long-run solution. Funds available for the program total $1.5 million, about 1.5% of ARPA's ballistic missile defense budget.

The program is known as GLIPAR standing for Guide Line Identification Program for Anti-Missile Research. Phase I will last nine months. It will consist of six months of study by some 5-10 contractors of possible advanced defense mechanisms, one month for preparation of technical summary reports, and a final two months' working meeting where representatives of the individual contractors will combine their results into a "single cohesive evaluation" to provide a basis for action by ARPA.

Some scientists have ridiculed consideration of such concepts as anti-gravity for missile defense. ARPA emphasizes, however, that the GLIPAR program is an attempt to break loose scientific thinking from conventional approaches to the missile defense problem so that all potentially applicable physical mechanisms can receive unprejudiced examination.

Potential bidders received a briefing on the GLIPAR program at the Pentagon Feb. 20 from personnel of the Ballistic Missile Defense Branch of ARPA's Institute for Defense Analyses. About 50 major airframe and electronics companies plus several university groups attended.

One of ARPA's responsibilities is research and development leading to advanced capabilities in ballistic missile defense. Phase I of the GLIPAR program is aimed at setting out initial guide lines for research to develop such capabilities some 12 to 20 years in the future.

The threat for this period is defined as any offensively "thrown" matter directed at the United States, including specifically any matter traveling along a path which in any part is essentially ballistic. The destructive potential of the threat is not limited to nuclear warheads.

The countermeasures to be sought must come close to being totally effective in preventing the threat from carrying out its mission. Those measures which give basic advantages to the defensive operation will have the highest values. The objectives of Phase I are to identify and assign relative value to the advanced defensive mechanisms which have maximum potential.

The program will not require demonstrations of feasibility. Instead, it will require rigorous or detailed semi-rigorous proofs that a particular mechanism is not feasible. Approaches which appear to be valuable and which cannot be proved not feasible, will be kept for further consideration.

Proposals for Phase I must be submitted to ARPA by Mar. 20. The nine-month study contracts to be awarded will each involve approximately 50 man-months of highly competent technical time. The proposals will be examined by an advisory committee made up from the three services and ARPA, with ARPA making the final selection of some 5-10 contractors about April 3.

The first six months of each contract will be spent in study in the individual contractor's laboratories. Each will have the freedom to select the mechanisms or physical phenomena for missile defense to be examined—and each should expect to examine closely some 5 to 15 possibilities, according to ARPA.

The basic conservation laws of physics will be applied to develop those characteristics of the mechanisms selected that will permit their evaluation for missile defense. Engineering difficulties are to be of no concern in the studies, but the appropriate physical laws must be satisfied throughout.

At the end of the sixth month each contractor will prepare a summary report covering the work accomplished. This is expected to take one month.

The contractors will then provide one representative each to participate in a working meeting that will last for a maximum of two months. This meeting will combine the individual results into a group evaluation to be used by ARPA as a basis for deciding on Phase II.

Phase I may indicate that the philosophy behind the Army's Nike-Zeus anti-missile missile system—that of firing a rifle bullet to intercept a rifle bullet—is the only practical approach to missile defense for the foreseeable future. If, however, the program uncovers more promising approaches, ARPA will push development.

Two objections appear to have been raised to the program. At the bidder briefing, a representative of the Bell Telephone Laboratories stated that he did not believe Bell would be interested in participating because the six month's limitation on laboratory study appeared to be placing a time limit on achievement of a breakthrough.

Others present at the briefing objected to the small number of university research groups present. ARPA states, however, that only the space available for the briefing limited the number of invitations, and that unsolicited proposals for program studies would be given equal consideration.

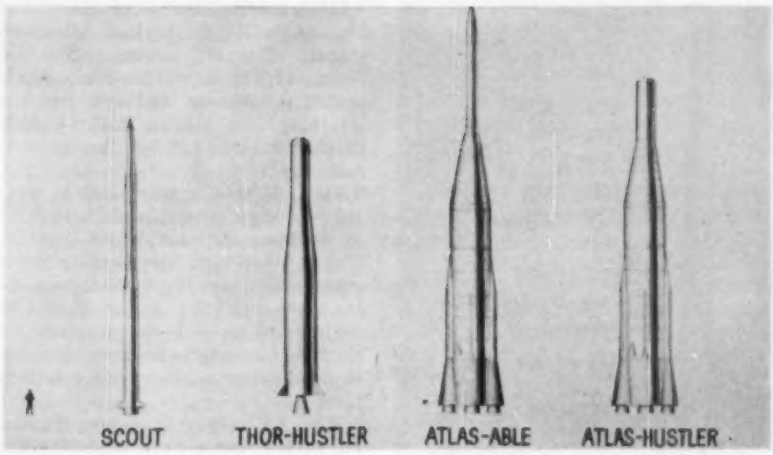
Cornell Studying High Power Radar

Buffalo, N. Y.—Problems of microwave propagation in long range missile tracking and development of very high power microwave radars will be explored by Cornell Aeronautical Laboratory under a $1.3 million contract awarded last month by U. S. Army Ordnance Corps, acting as contracting agency for the Advanced Research Projects Agency.

The program will be a continuation of high power radar studies originating with the laboratory's work on the Plato anti-missile missile system and a later $200,000 Army contract which ended last fall. The earlier program resulted in successful transmission of 21 million watts of peak power at S-band frequencies.

The new project will aim at transmission of peak powers as high as 50 million watts, with a variety of pulse lengths and repetition rates. Average power may be raised to 50,000 watts.

Also included in the studies will be investigations of propagation phenomena that may limit the utility of future microwave radars in such applications as the tracking of intercontinental ballistic missiles.



SPACE probe vehicles soon available range from Scout to three-engined Atlas-Hustler.

Space Technology

U.S. Plan for Rocket Vehicles Includes Manned Flight to Mars

By Evert Clark

Washington—U. S. is planning a family of rocket vehicles for a variety of missions ranging up to a manned round trip to Mars. All propulsion stages for vehicles in this long-range plan either exist now, are under development or in the feasibility study stage.

National Aeronautics and Space Administration officials outlined the plan to the Senate Committee on Aeronautics and Space Sciences.

Vehicles toward the far end of the time scale would put satellites of up to 42,000 lb. into a 22,000 mi. orbit, put a 19,900 lb. payload on the moon, and send a 55,000 lb. payload to Mars, providing for a 25,000 lb. return payload.

Vehicles in the order of payload capability, and roughly in the order of their availability, are:

• **Project Scout**—150 lb. payload in a 300 mi. orbit, or heavier loads in lower orbits. This is a 70-ft., 35,000 lb. four-stage solid propellant vehicle now being developed for NASA (see story on p. 22). Air Force also will use a version of this vehicle. Initial tests are due by mid-1960.

• **Thor-Hustler.** This is the Douglas Thor missile booster plus Bell Aircraft Corp.'s Hustler engine, which uses JP-4 and red fuming nitric acid. It is in use in Advanced Research Projects Agency's Discoverer military satellite program (AW Feb. 16, p. 30).

• **Atlas-Able.** This is the Convair Atlas missile booster with the same upper stages used in Thor-Able vehicles—Aerojet's Vanguard second-stage liquid fueled engine and Allegany Ballistic Laboratory's Vanguard third-stage solid propellant engine plus a payload stage. Under present plans, this will be used for the first time on June 4 in an attempt to send a payload into orbit around the planet Venus (AW Feb. 23, p. 26).

• **Atlas-Hustler.** Atlas booster plus the Bell Hustler upper stage. This could put some 3,000 lb. into a 300 mi. orbit.

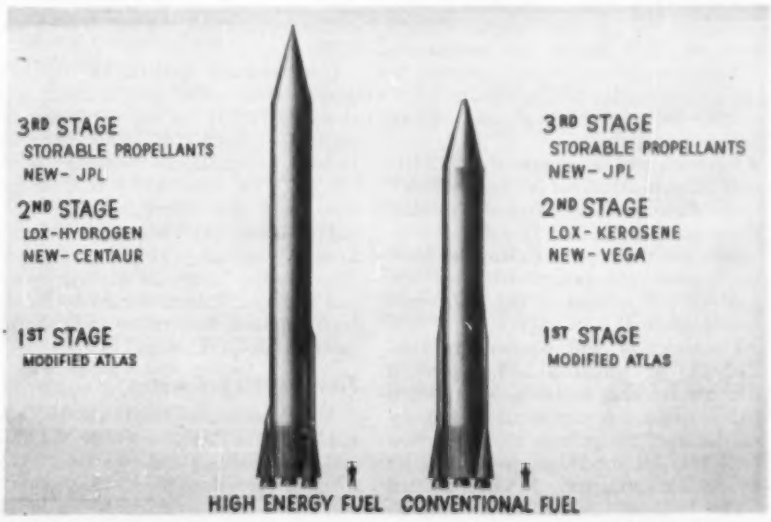
• **Vega.** This vehicle is now under development by ARPA. It uses an Atlas first stage, General Electric X-405 Vanguard first-stage engine as its second stage. Initial Vega vehicle would consist of just these two stages. Later version would use a 6,000 lb. thrust storable liquid engine now being developed by NASA's Jet Propulsion Laboratory and probably will be ready in less than two years.

• **Centaur.** This would use a modified Atlas with high-energy fuels as a first stage, the 15,000 lb. thrust liquid oxygen and hydrogen Centaur stage now being developed by Convair and Pratt & Whitney as a second stage and a storable liquid third stage. The Centaur engine is under ARPA supervision now but will transfer to NASA on July 1. NASA refers to the entire vehicle as Centaur rather than just to the stage. Storable stage may be the 6,000 lb. thrust JPL engine or a 20,000 lb. thrust storable engine now under study. The Centaur vehicle may be ready in about three years.

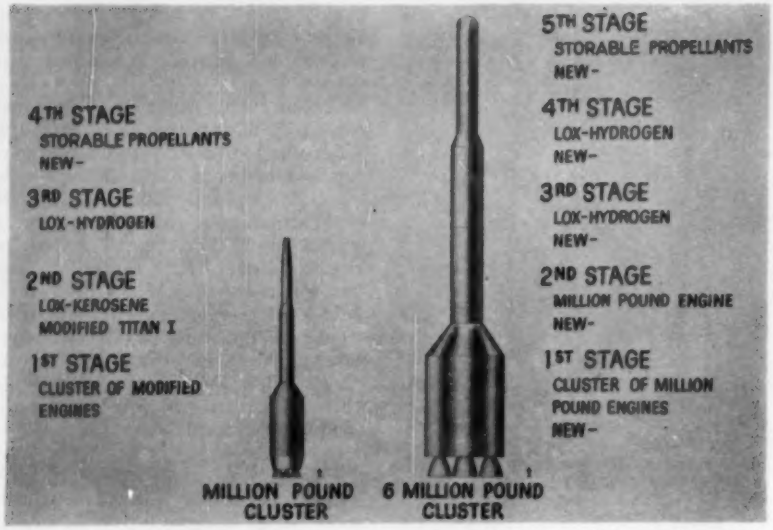
• **Saturn.** This is based on the 1.5-million lb. thrust Rocketdyne cluster now being developed for ARPA by Army Ballistic Missile Agency. First vehicles may have only two stages. Upper stages for a four-stage vehicle have not been made final but present planning calls for the cluster topped by a modified Titan I; a liquid oxygen and nitrogen third stage—possibly the Centaur—and a storable liquid fourth stage. Early vehicles are expected to be ready for flight in 1960.

• **Nova.** This a vehicle of up to five stages, depending upon the mission, and based upon a cluster of four of the 1.5-million lb. thrust single-chamber engines now being developed for NASA by Rocketdyne. Second stage would be a single one of these engines; third and fourth stage would be a new liquid oxygen and hydrogen engine and the fourth would be a storable liquid engine.

• **Vehicle using nuclear upper stage** or stages. The Atomic Energy Commission-NASA Rover nuclear rocket project



CENTAUR space probe configuration is at left; Vega (right) is under ARPA development.



SIZE of advanced boosters can be seen by comparison with figures of men at base level.

is aimed at eventually providing these stages.

They probably would be placed atop the six million lb. cluster.

Vehicle availability for putting various payloads into orbits or sending them into space is expected to run this way:

• **300 mi. orbit**—Vehicles now can put up 100-150 lb. and vehicles available soon can orbit 2,000 lb. Atlas with staging—which could be Vega or Centaur—could put up 7,400 lb. Saturn could orbit 19,000 to 25,000 lb. and Nova could orbit 150,000 lb.

• **22,000 mi. orbit**—First vehicle with this capability will be Atlas plus staging, with a payload of 1,300 lb. Saturn could orbit 3,300 lb. and Nova could orbit 42,000 lb.

• **Lunar landing**—Vehicles available soon can send a 300 lb. payload Atlas with staging, 730 lb.; Saturn, 1,800 lb.; Nova, 19,900 lb. The Nova would not be suitable for landing a man and returning him because payload drops to the vicinity of 2,000 lb. for a return trip.

• **Mars flight**—Chemical stages, probably the Nova vehicle, could send 7,500 lb. to Mars and provide for returning 750 lb. A vehicle using nuclear upper stages could carry a 55,000 lb. payload to Mars, providing for a 25,000 lb. return—which should be enough by the time this vehicle is ready to allow for manned reconnaissance and return to earth.

The 1.5-million lb. single chamber engine is expected to be available sometime between three and six years from now.

By the time it is ready for use, these upper stages are expected to be ready, in this order:

• **6,000-lb. thrust storable** liquid engine under development by Jet Propulsion Laboratory.

• **15,000-lb. thrust liquid** oxygen and hydrogen engine under development by Convair and Pratt & Whitney.

• **80,000-lb. thrust liquid oxygen** and hydrogen engine now under study.

• **20,000-lb. storable liquid** engine now under study.

Space Technology

NASA Asks $49 Million Supplemental

By Ford Eastman

Washington—National Aeronautics and Space Administration is requesting $48,354,000 in supplemental funds for Fiscal 1959—a figure more than $3 million above the amount Congress slashed from the 1959 budget last summer.

Supplemental estimates presented to the subcommittee of the Senate Committee on Aeronautical and Space Sciences include:

• **Research and development,** $20,750,000, all earmarked for NASA's manned space flight program, Project Mercury. Congress knocked $20.02 million for research and development estimates from the Fiscal 1959 budget last year, approving $50 million of the $70.2 million requested.

• **Construction and equipment,** $24,250,000, of which $12.05 million is for new tracking facilities, $3.2 million for propulsion-development testing facilities and $9 million for other new facilities and modifications at the Jet Propulsion Laboratory. NASA requested $47.8 million for this in its original Fiscal 1959 budget request; Congress reduced the figure by $22.8 million to $25 million.

• **Salaries and expenses,** $3,354,000 to cover cost of salary increases provided by the Classified Pay Act of 1958. Congress approved $5 million of the $7 million requested last summer for Fiscal 1959.

Congressional approval of the 1959 supplemental would give NASA a total of $384,073,532 for the fiscal year, including a transfer of funds from the Defense Department totaling $154,619,532. Of this, $57.8 million was transferred from the Air Force, $67.2 million from the Advanced Research Projects Agency, $25,541,282 from Navy for the Vanguard satellite project and $4,078,250 from the Army for the Jet Propulsion Laboratory of California Institute of Technology.

Fiscal 1960 Estimates

NASA estimates for Fiscal 1960 total $485.3 million, of which $94,430,000 is for salaries and expenses, $333,070,000 for research and development and $57.8 million for construction and equipment. T. Keith Glennan, NASA administrator, told subcommittee chairman Sen. John Stennis (D.-Miss.) that additional funds probably would be required during Fiscal 1960 under a supplemental appropriations request. Congress has yet to take the Fiscal 1960 requests under consideration.

Glennan added that, in his opinion, this would be the last year NASA would request a budget as small as one-half billion dollars. He estimated that the figure would reach $2 billion in two years.

Two major projects now under way that will require sizable portions of research and development funds during the next few years, Glennan said, are Project Mercury and propulsion programs.

Project Mercury already is budgeted at $37,661,200 in Fiscal 1959 and another $20,750,000 is requested under the supplemental. Cost of the project in Fiscal 1960 is estimated at $70 million. Before the program is completed, Glennan said the bill will have exceeded $200 million.

The single-chamber 1.5 million lb. thrust booster under development by

orth American Aviation is budgeted at $12 million in Fiscal 1959 and $30.2 million in Fiscal 1960, Glennan told the subcommittee. However, before the single chamber booster reaches a state of usefulness, the cost will have exceeded $200 million.

Total cost of the national booster program to provide the building block units of basic rocket engines required for the space program, Glennan added, will exceed $2 billion.

Out of the $24,250,000 requested for construction and equipment, $9 million is for new facilities and improvements to existing facilities at the Jet Propulsion Laboratory. A large part of this will be used to relocate various rocket test facilities and related equipment to a non-hazardous location where safety code standards can be met.

At present, all but 10 of the 92 facilities on the laboratory site in Pasadena are non-conforming, Glennan said. Modifications to existing facilities to meet changing requirements would involve major alterations.

Necessary land acquisition will cost $375,000. Relocation of utilities will total $2,775,200; relocation of test facilities $1,931,800. Modernization of support facilities will cost $2,255,000. Necessary new facilities will cost $1,488,000 plus $175,000 for a new substation and transformer pad.

The largest item under construction and equipment is the $12,050,000 requested for tracking facilities, which Glennan says are needed now because of the long lead times of much of the electronic gear.

Glennan told the subcommittee experience gained during the initial operation of the Minitrack electronic tracking stations in the International Geophysical Year program proved the need for improving and augmenting existing systems to provide more reliability and increased capability for tracking satellites in high inclination orbits.

New Tracking Stations

To accomplish these objectives, it is planned to establish four new electronic tracking stations in Alaska, the U.S., Newfoundland and Europe and to install additional, improved equipment at some of existing Minitrack stations.

Improvements will include addition of real-time digital data read-out equipment and additional antenna arrays for coverage of satellites in high inclination orbits. It also will be necessary to shift the operation of all stations to a higher radio frequency since the 108 mc. frequency now used is temporary. To make the frequency change, reworking of all Minitrack radio receiving equipment and antenna arrays will be required.

Tracking and reception of telemetry data from space probes will require the provision of special high-gain, low-noise receiving systems at several points on the earth's surface. One has been built at Goldstone, Calif., and funds requested are for two more, one in Australia and the other in South Africa. Each station will include large parabolic-antenna units to pick up the low-level signals, sensitive radio receiving equipment and electronic-hydraulic servo system for controlling the antenna.

Detailed studies of the problems of recovering earth satellites, particularly manned systems, Glennan said, established the desirability of northeast launchings from Cape Canaveral with recoveries on the second and third orbits along the existing Atlantic Missile Range complex.

Such operations will require the installation of precision radar acquisition, tracking, communication and associated systems at Bermuda in order to provide accurate trajectory information on the satellite after booster cutoff to establish that the satellite is in the desired orbit and to initiate abort action if unsatisfactory.

Recovery of a manned satellite on the second and third orbit will require precision tracking during the re-entry phase, Glennan told the subcommittee. He hopes to provide precision radar acquisition, tracking, communications and associated systems in Hawaii to provide initial impact point prediction during the first phase of satellite re-entry.

Emergency Control

This station also will provide a capability for emergency command control of retrorocket firing in the satellite in the event of malfunctioning of the preset timer systems.

Glennan said still another precision radar acquisition, tracking communica-

NASA Research, Development Programs—Fiscal 1959 & 1960

Program	Allotments	Fiscal 1959 Supplemental Estimates	Fiscal 1960 Regular Estimates
AIRCRAFT, MISSILE, AND SPACE-CRAFT RESEARCH:			
Support of NASA plant	$338,800	.....	$16,670,000
Support of JPL plant	8,156,500	.....	8,156,500
Research contracts	5,500,000	.....	8,200,000
SCIENTIFIC INVESTIGATIONS IN SPACE:			
Sounding rockets	5,000,000	.....	10,000,000
Earth satellites	44,000,000	.....	61,800,000
Lunar probes	20,021,750	.....	24,043,500
Deep-space probes	16,000,000	.....	22,500,000
Vanguard program	25,541,282	.....	.....
SATELLITE APPLICATIONS INVESTIGATIONS:			
Meteorology	3,400,000	.....	15,000,000
Communications	4,700,000	.....	13,000,000
SPACE OPERATIONS TECHNOLOGY:			
Manned space flight	37,661,200	$20,750,000	70,000,000
Space rendezvous techniques	.....	.....	3,000,000
SPACE PROPULSION LABORATORY:			
Solid fuel rockets	700,000	.....	3,000,000
High-energy fuel rockets	7,000,000	.....	17,000,000
1-million pound thrust single chamber engine	12,000,000	.....	30,200,000
Nuclear rocket engines	8,500,000	.....	8,000,000
Space engines	300,000	.....	3,000,000
Auxiliary power units	500,000	.....	3,000,000
SPACE SYSTEMS TECHNOLOGY:			
Advanced vehicle systems	500,000	.....	1,500,000
Booster recovery systems	500,000	.....	1,500,000
Orbiting space laboratories	.....	.....	2,000,000
SUPPORTING ACTIVITIES:			
Tracking and data acquisition	4,300,000	.....	11,500,000
TOTAL, RESEARCH AND DEVELOPMENT	$204,619,532	$20,750,000	$333,070,000

tions and associated systems station is needed to track a re-entering satellite between the western and eastern area of the U. S. He proposed that the station be located in southern Texas and equipped for precision tracking of satellites launched northeast from Cape Canaveral on the first three orbits.

Cost breakdown includes:

• **Extension and improvement** of satellite electronic tracking stations, $3.3 million. Of this, $2,124,000 is for equipment and facilities for four new stations, including $110,000 for antenna arrays, $346,000 for electronic equipment and $75,000 for site preparation and utilities. Another $1,176,000 of the total is for modification and improvement of existing electronic tracking stations, of which $720,000 will go for rework of 12 stations to change radio frequency, $156,000 for digital read-out equipment and $300,000 for antenna arrays at six stations.

• **Facilities for space probe** tracking network, $3.5 million. Of this amount, $1.9 million is for initial site preparation, roads, utilities and housing at two stations; $950,000 for two 85-ft. diameter antenna systems; $460,000 for two radio receiving units, and $190,000 for two antenna servo control systems.

• **Equipment for support of manned** space vehicles, $5,250,000. This includes $1,750,000 for precision radar system for insertion tracking and guidance, $1,750,000 for precision radar for initial re-entry tracking and control and $1,750,000 for precision radar for mid-course and landing tracking.

Space Technology

NASA Awards Scout Contracts

Washington—Contracts for the 70-ft., 35,000-lb. Project Scout general purpose space rocket (AW Feb. 2, p. 26) have been awarded by National Aeronautics and Space Administration, and Air Force is in the process of selecting contractors for Scout's military counterpart.

NASA and USAF will supervise development with a joint team. USAF's vehicle—System 609A—will differ from Scout in several respects.

Both are intended to be modular rockets with stages that can be used in various combinations. All Scout stages are solid propellant. With the possible exception of the third stage, all are off-the-shelf items.

Scout will be assembled at Langley Research Center and fired initially from the nearby Pilotless Aircraft Research Station at Wallops Island, Va. Assembly contract has not yet been awarded.

Basic Scout consists of four stages and could put 150 lb. into orbit or send a payload of about 100 lb. to an altitude of 5,000 mi. It also will be used in high-speed re-entry tests. Stages and contractors are:

• **First stage**—Aerojet-General Corp.'s Aerojet Senior, with more than 100,000 lb. of thrust. This engine originally was called Jupiter Senior when the Jupiter intermediate range missile still was a joint Army-Navy project. At the time it was the largest solid engine that had been fired. It powered an early Polaris test vehicle. Contract, let through Navy's BuOrd, totals $1,020,000.

• **Second stage**—Thiokol Inc.'s improved Sergeant rocket designated TX-33-20. Contract is awarded through Army Ballistic Missile Agency and totals $620,000.

• **Third stage**—Allegany Ballistic Laboratory's X-254 engine, a scaled-up version of the X-248 third stage engine developed for the Vanguard satellite vehicle. Scale-up may be as high as three or four times the X-248's thrust, which is about 2,500 lb. Contract is let through BuOrd, and totals $1,120,000.

• **Fourth stage**—Allegany's X-248 engine, which will be used in Vanguard and has been used in Thor-Ables and USAF lunar probes. Contract is through BuOrd, totals $100,000.

The NASA program also includes a $90,000 contract for Thiokol XM-45 rockets. Same type of rocket will be used as escape rockets in the Mercury manned capsule project. NASA has not explained what their use would be in the Scout program, but it may be for spin stabilization or retrorockets. Contract is let through ABMA.

Guidance and spin stabilization control for the fourth stage will be done by Minneapolis-Honeywell Corp.

Rocket Contracts Let For Project Mercury

Washington—Contracts for rocket vehicles to be used in four phases of Project Mercury, including a solid-propellant Little Joe vehicle for the first phase, have been awarded by National Aeronautics and Space Administration.

Another shot, designated Big Joe and using an Atlas, will be fired sometime this summer. Atlas will carry the beryllium heat shield and some other heavy components of the manned capsule to a great height on a near-vertical trajectory to test re-entry heating.

Little Joe is the transport vehicle for the first full-scale capsule tests. Details of the vehicle and the concept of its operation were first revealed by AVIATION WEEK on Dec. 15 (p. 26). North American Aviation's Missile Division will provide seven vehicles and a launcher under a $400,000 contract.

Thiokol, Inc.'s improved TX-33-20 and TX-33-22 Sergeant rockets used in Polaris test vehicles will provide the thrust, being ignited in pairs, and Thiokol XM-19E1 Recruit rockets will be arranged around the main rockets to provide a high initial boost. Sergeant contract is for $2.2 million and was let through Army Ballistic Missile Agency. Recruit contract is for $110,000.

This first phase program also includes a $120,000 contract to ABMA-Thiokol for XM-45 capsule escape rockets.

• **Second phase of Mercury testing** will use Chrysler Redstone boosters equipped with capsules that will carry animals and, on later shots, possibly a man. Contract to Army Ordnance Missile Command for Fiscal 1959 is $4.49 million, with the final contract cost expected to reach $15.5 million.

• **Third phase will use Chrysler** Jupiter boosters and also will include use of animal capsules and probably manned capsules fired on less-than-orbital trajectories. Contract to Army Ordnance Missile Command for Fiscal 1959 is $2.74 million; total contract cost is estimated at $4.45 million. ABMA will make the necessary modifications to the Chrysler-produced Redstones and Jupiters.

• **Fourth phase will use Convair** Atlas D boosters the vehicle which will put the manned capsules into orbit. Two contracts have been let through Air Research and Development Command's Ballistic Missile Division for Fiscal 1959, one for $1.4 million and the other for $5.6 million.

Contracts already awarded (see p. 44) call for one Atlas-Able and two Thor-Ables (AW Feb. 23, p. 26) and one improved vehicle—possibly an Atlas topped by the General Electric X-405 Vanguard engine—all for firing in 1959 and 1960; at least four to six Juno II boosters for satellites and space probes; $140,000 to Minneapolis-Honeywell Regulator Co. for automatic flight control systems for Project Mercury; and contracts for rocket thrust chambers and tooling and propellant tank assemblies for a liquid hydrogen rocket test program at Lewis Research Center.

Also included is $2.15 million for the orbiting of a 100-ft. inflatable sphere of plastic coated with aluminum, which will serve as a passive communications satellite. Originally, the plan was to send it up this year, using a Juno vehicle, but present plans call for launching in 1960 with either a Thor-Able I or some improved vehicle.

Contract is with Army Ordnance Missile Command.

National Aeronautics and Space Administration

Functional Breakdown—Research and Development—Fiscal 1960

Program	Contracts For: Scientific and technical studies	Prototypes and operational hardware	Operations and technical services	Supplies, equipment, repairs, and alterations	Total
AIRCRAFT, MISSILE, AND SPACE CRAFT RESEARCH:					
Support of NASA plant	.....	.....	$1,049,000	$15,621,000	$16,670,000
Support of JPL plant[1]	.....	.....	.....	.....	8,156,500
Research contracts	$8,200,000	.....	.....	.....	8,200,000
SCIENTIFIC INVESTIGATIONS IN SPACE:					
Sounding rockets	500,000	$6,000,000	1,500,000	2,000,000	10,000,000
Earth satellites	3,000,000	46,000,000	9,800,000	3,000,000	61,800,000
Lunar probes	3,000,000	17,443,500	2,600,000	1,000,000	24,043,500
Deep-space probes	4,000,000	17,000,000	1,000,000	500,000	22,500,000
Vanguard program[1]	.....	.....	.....	.....	.....
SATELLITE APPLICATIONS INVESTIGATIONS:					
Meteorology	1,200,000	8,000,000	5,000,000	800,000	15,000,000
Communications	1,500,000	6,500,000	4,000,000	1,000,000	13,000,000
SPACE OPERATIONS TECHNOLOGY:					
Manned space flight	1,300,000	49,700,000	13,000,000	6,000,000	70,000,000
Space rendezvous techniques	1,000,000	1,500,000	.....	500,000	3,000,000
SPACE PROPULSION TECHNOLOGY:					
Solid fuel rockets	800,000	1,800,000	.....	400,000	3,000,000
High-energy fuel rockets	3,400,000	13,600,000	.....	.....	17,000,000
1-million lb. thrust single chamber engine	.....	30,200,000	.....	.....	30,200,000
Nuclear rocket engines	2,000,000	5,500,000	200,000	300,000	8,000,000
Space engines	1,000,000	1,800,000	.....	200,000	3,000,000
Auxiliary power units	200,000	2,700,000	.....	100,000	3,000,000
SPACE SYSTEMS TECHNOLOGY:					
Advanced vehicle systems	1,200,000	.....	.....	300,000	1,500,000
Booster recovery systems	1,200,000	.....	.....	300,000	1,500,000
Orbiting space laboratories	900,000	900,000	.....	200,000	2,000,000
SUPPORTING ACTIVITIES:					
Tracking and data acquisition	800,000	1,500,000	7,500,000	1,700,000	11,500,000
TOTAL RESEARCH AND DEVELOPMENT	$35,200,000	$210,143,500	$45,649,000	$33,921,000	$333,070,000

[1] Functional breakdown not available.

35,000-ft. Sled Track Tested

Holloman AFB—Air Force formally inaugurated its 35,000 ft. high speed test sled track last week with a supersonic run in which two live rats were used in a g-force study.

Test sled carrying the rats was boosted to a speed of 1,090 mph. by an Astrodyne Megaboom solid rocket motor that delivers 100,000 lb. of thrust during its 10 sec. firing period. Sled traveled nearly 30,000 ft., coasting to a stop before it reached the water brake at the end of the track.

During the inaugural run, vibration characteristics of equipment aboard were tested and studies were made of a new anti-g chamber developed by Harald von Beckh, technical director of the Aeromedical Field Laboratory. One of the rats rode in a trapeze-type rig in which it swung into a position where g forces acted transversely during acceleration, then swung around to a new position to get the transverse effect during deceleration. The second rat rode in a head-to-toe position to provide a comparison. Both rats survived the trip.

Astrodyne solid propellant booster was one of a type using modular design concept in which various extruded sizes and shapes of propellant are combined to provide the propulsion needed for a particular test run. This modular approach lends flexibility to test operations by permitting researchers to tailor the booster precisely to the requirements of a particular run.

Astrodyne has developed its capability for producing small extruded ammonium nitrate solid propellant grains through experimental programs and through a JATO production program which is now phasing out at the company's McGregor, Tex., plant.

Megaboom booster used to propel the sled was constructed of ammonium nitrate extruded propellant segments assembled to meet specifications for the job and held in place by a system of steel rods and plates.

Several Megaboom motors have been used for track missions at Holloman in the past.

Booster used in the sled run last week was produced nearly two years ago by Rocket Fuels Division of Phillips Petroleum Co. before this division was absorbed by Astrodyne, a subsidiary of Phillips and North American Aviation. The 21 ft. 11 in. motor was hauled 2,000 mi. by truck and stored under varying climatic conditions before firing.

Megaboom booster was 38⅝ in. in diameter, weighed 3,934 lb. empty and 9,460 lb. loaded.

Process of Decision

Washington—President Eisenhower was asked at his press conference last week about what a reporter termed "great discrepancies" in testimony by military experts on the Fiscal 1960 budget "as to whether we have adequate defense."

". . . Is there not some way to avoid public confidence being undermined," the reporter asked, "and in view of the international situation, is there not some way that we can get these leaders and yourself to arrive at a reconciliation of views as to what we actually need for defense?" Following is the President's reply:

"Well, I'm a little astonished at that question. I have been, certainly, all my life in this same problem. For the last six years I have had the final responsibility so far as the executive department, and as my position as Commander-in-Chief are concerned.

"Now, very naturally there are conflicting views in any proposal that humans make. I would doubt that you could find any three people sitting in this room who, with respect to their idea of the way a newspaper ought to be operated, would give you identical views.

(Laughter).

"Now, you are certainly not going to get such identical views in people who, themselves, believe that in their service, in their own function, lies the safety of the United States. Someone has to—has to make the decision. That happens to be the Commander-in-Chief.

"Now, and I must say this, and I think possibly this is the first time that I have ever violated my own conception of humility and modesty: I think I am more able than any one of those individuals of whom you speak to make an over-all decision on behalf of the United States in this vital matter, because I again assure you that just by spending money does not make us stronger. Indeed, if you spend too much money, you will make us weaker. That is when the nicety of judgment comes in—what do we need; get that; get that by all means, and get no more.

"And remember, our system is a balanced one. We should not concern ourselves so much with one single item. Somebody makes a demagogic talk about a missile, or somebody else about a different submarine or a piece of radar. You have got a whole level of balanced types of equipment, training, organization, and strategy that we believe fits our system.

"As a matter of fact, just two or three nights ago Adm. Burke made a speech somewhere, I believe in Carolina, on this subject, and I thought it was indeed good."

(In his speech, Adm. Burke said: "Whether the USSR has one-half as many or several times as many missiles as the United States is really academic as long as we have the assured capability of destroying Russia and as long as the Soviets know it and are really convinced of it.")

Navy Variable Thrust Liquid Rocket Tested

Lake Denmark, N. J.—Naval Air Rocket Test Station here has designed, made and tested an advanced, variable thrust, liquid propellant rocket engine.

Additional firings are now under way to confirm initial data, and a complete report will be made in about two months.

Throttlability in liquid rocket engines is not, of course, a new achievement. The French and British have been using throttled engines for a number of years. In the United States, the Reaction Motors and Curtiss-Wright powerplants for the X-1, X-2 and X-15 aircraft were and are throttlable to some degree. And Naval Ordnance Test Station (see p. 43) recently developed throttle-controlled prepackaged liquid propellant engines.

The significance of the new NARTS system lies in its "unique" capability of maintaining optimum chamber pressure throughout the variable thrust range. In earlier engines which were throttled just at the injector to control propellant flow, there was usually a sharp fall-off in pressure and the danger of combustion instability when the flow rate was cut back.

To avoid this problem and maintain optimum chamber pressure, NARTS scientists have gone to a dual throttling system in which the rocket engine is throttled both at the injector and at the throat. This arrangement is reported to give engines a 20-to-1 throttling capability and can be used with either pump or pressure-fed powerplants, using prepackaged or the most current cryogenic propellants.

Almost every liquid rocket powerplant from small verniers and drone engines up through the prime propulsion systems for missiles and manned rockets are potential candidates for the new thrust control system, according to NARTS.

Adapted to existing rocket engines, the new dual throttling system could be in production and operational in a year. It would take longer, of course, to develop and produce a completely new engine with the new throttling arrangement.

U.S. Navaid Wins ICAO Recognition

Montreal—After one of the most bitterly fought technical arguments of recent years, the U. S. gained recognition of its VOR/DME-T as the international standard short range navigation aid. Contesting the decision were the British and Commonwealth supporters of the Decca system (AW Feb. 16, p. 35) here at the special meeting on short distance navigation aids of the International Civil Aviation Organization.

Voting at the meeting last week was:

- **For continuation of VOR** as the international standard short range aid for terminal and en route areas: 34 in favor, none opposed, 2 abstentions.
- **For extending** the protection date for VOR (the period during which it shall remain an international standard) to Jan. 1, 1975: 28 in favor, 1 opposed, 6 abstentions.
- **For modifying** the present recommended DME standard to meet the specifications of DME-T: 30 in favor, 4 opposed, 6 abstentions.
- **For adoption** of DME-T as an international standard, to be installed in conjunction with VOR where required—the most hotly contested issue of the meeting: 20 in favor, 4 opposed, 12 abstentions.
- **For establishing** a protection date of Jan. 1, 1975, for the DME-T standard: 24 in favor, none opposed, 11 abstentions.

Although the principal issue of the meeting was decided in this voting last week, the meeting will continue this week for the purpose of formally determining the final language of the new standards.

The British are expected to fight a stiff rear-guard action in an effort to gain some type of official recognition of the Decca system in the ICAO recommendations.

Victor B.2 Bomber Makes First Flight

London—Handley Page Victor B.2 bomber made a successful maiden flight last week. The plane is the first production aircraft to fly with Rolls-Royce Conway bypass engines. It has four, each of 17,250 lb. thrust.

Among the new features of the B.2 is a small Blackburn Artouste turbine engine built into the starboard wing root. It drives a generator providing emergency power in low level flight, and provides air pressure to start starboard engines. Port engines are started by air pressure from the starboard ones, making the aircraft independent of ground starting supplies.

Canada Seeks U.S. Defense Contracts

By J. S. Butz, Jr.

Ottawa—Canada hopes to claim an increasing share of U. S. defense production contracts to help offset the effects of its controversial decision to rely primarily upon U. S. weapon systems for its own aerial defense.

Tentative plans to give Canadian industry access to the U. S. defense procurement program, and Canada's hopes for substantial U. S. business, were made known as an aftermath of the Canadian government's decision to cancel the Mach 3 Avro CF-105 Arrow interceptor and the Orenda Iroquois turbojet engine contracts. Both contracts had been widely subcontracted to Canadian industry and provided the principal support of a large percentage of the Canadian aircraft complex, the nation's third largest industry.

Other Developments

Other developments:

• **Cancellations left long-range future** of the two firms and of the "flying saucer" annular jet project under development by Avro for USAF and the U. S. Army in doubt. However, Avro hopes to continue development of the annular jet program and still has contracts for the modification of CF-100 aircraft for the Royal Canadian Air Force.

• **On the day the cancellations** were announced, all employes of the Avro and Orenda companies, approximately 13,800 engineers and production workers, were discharged. Two firms now have enough work to keep between 2,000 and 4,000 persons at work. Many of these already have been recalled, but only a small portion of the total are design engineers, and the exodus to the U. S. apparently already has begun.

• **Government's position** was that the Arrow decision had been made primarily on military grounds but that Canada also was seeking the best defense bargain it could find when it decided to rely almost exclusively upon the Boeing Bomarc interceptor missile for aerial defense. Prime Minister John G. Diefenbaker said:

"I say with all of the seriousness that I can put at my command that the production of obsolete weapons as a make-work program is an unjustifiable expense of public funds."

• **Opposition, in turn, charged** that the Bomarc had originated as a "make-work" program for Boeing.

Only concrete evidence the government could offer to back its hopes for increased U. S. defense business was the award of a $1.7 million subcontract by Boeing to Canadair for the production of Bomarc wing and tail sections.

However, according to U. S. sources, more than 100 Canadian firms have been invited to participate in bidding for other Bomarc subcontracts, and 180 Canadair engineers are working on loan in Seattle on Boeing's missile program (AW Feb. 23, p. 25).

Canadian subcontractors will participate in the complete production program, not just on those missiles earmarked for the RCAF.

What Canada Wants

Raymond O'Hurley, Canadian Minister of Defense Production, says the government's present aim is to ensure equal opportunity for Canadian firms in bidding on U.S. contracts and that, once this is achieved, "the real success of production sharing endeavors depends to a large degree upon the determination of Canadian industry vigorously to seek defense business in the U.S. as either prime or subcontractors."

O'Hurley added that Canadians would have to become competitive with U.S. industry in terms of technical competence, delivery and price.

One potential hitch in Canada's plans is the Buy America Act which is still in effect in the U.S. It requires, in many instances, that foreign bids for U.S. defense business be subject to duty and also must be raised by approximately 6% when its bid is considered alongside those of U.S. firms. It has not yet been determined whether the act will apply under the present loose U.S.-Canadian arrangements initiated last December.

Canadian ability to compete for prime U.S. contracts also may be seriously limited if the Avro and Orenda engineering and management forces are not held intact.

The government apparently believes that the principal Canadian opportunity will be subcontracting to large U.S. primes. Opinion is widespread in the Canadian industry, however, that this will not work and that a definite agreement must be reached allotting Canada a definite portion of the production for mutual defense.

Feeling behind this is that the shrinking number of contracts available to the U.S. aircraft industry and the relatively large number of unemployed in the U.S. will combine to develop too great a political pressure to permit any sizable volume of business to leave the country.

One program that has been developed primarily with U.S. funds over the past several years—and because there was no comparable U.S. project—is Avro's Flying Saucer Project which the company describes as a "revolutionary type vertical takeoff aircraft."

The project utilizes the annular jet principle which offers the possibility of increasing lift as a vehicle enters the ground effect by a factor of 100 or more as compared with a lift increase of 15 to 20% for airplanes and helicopters.

Several firms are conducting small-scale experimental work along these lines, but Avro is expected to be the first by several years to fly a man-carrying version. Before the Arrow cancellation, first flight of the Flying Saucer was scheduled for sometime this spring or summer.

Project Cancellation

At the time of the cancellation of the CF-105 and Iroquois projects, Prime Minister Diefenbaker told the House of Commons that the primary reason behind the government's action was the belief that "events had overtaken the Arrow" and that it is now obsolete. He conceded that development of the aircraft was a significant technical achievement but offered no hope that the government could utilize the facilities of the Avro and Orenda companies in the immediate future.

Position of A. V. Roe, the holding company which controls both Avro and Orenda, was made shortly afterwards when the company accused the government of failing to give it any warning of the cancellation and of not meeting with its officials to discuss proposed development projects which could be useful to the nation and save the experience and ability that had been built into the engineering design groups at Avro and Orenda.

The matter was debated in the House of Commons the following day while normal business was suspended.

Parliamentary opposition to Diefenbaker did not challenge the cancellation of the Arrow program, and most Canadians, as well as members of Parliament, appeared to agree that

Air Launch Test

Cape Canaveral, Fla.—First of McDonnell Aircraft Corp.'s two-stage test vehicles for an air-launched ballistic missile (AW Jan. 26, p. 23) has been fired from the ground over the Atlantic Missile Range. Second stage is controllable. Missile was fired from an Honest John launcher. McDonnell is the third contractor in the feasibility study phase and developed the test vehicle with company funds. A number of firms are planning to bid in the competition for an operational version.

development of advanced weapon systems such as CF-105 is too costly for a nation of approximately 17 million people to undertake alone.

The government reiterated its position of relying upon the Boeing Bomarc interceptor missile for the aerial defense of Canada under an arrangement whereby the U. S. would bear two-thirds of the cost and Canada one-third.

Disagreement as to fact developed between the government and the company on several major points concerning the Arrow program, particularly total cost. The company said cost of production of 100 aircraft would be less than $4 million each; the government put the cost at approximately $7.8 million. The government figures were not seriously challenged during the debate in commons.

Another reason for the CF-105 cancellation, according to Diefenbaker, is that "already the U. S. Air Force has decided not to continue with the further development and production of U. S. aircraft" having the same general performance as the Arrow. During the debate in Commons, he identified the U. S. aircraft as the Convair F-106. Maximum speed of the F-106 is approximately Mach 2. The CF-105 has a potential of Mach 3.

Later in the debate, Diefenbaker, who read from Canadian newspaper and periodical reports to make many of his points, quoted an article which said that the Arrow was capable of speeds of above 2,000 mph. but only in short bursts.

Its Mach 3 speed would place the Arrow relatively close to the general performance category of the North American F-108, which is scheduled to be in development over the next several years.

It has been widely reported in Canada that the five Arrows now flying with Pratt & Whitney J75 engines have approximately equaled the world speed record of 1,404.19 mph. set by the Lockheed F-104. The sixth flight test Arrow now nearing its initial flight date will be powered by Orenda Iroquois turbojets which will increase the power available by 30% or more for approximately the same engine weight.

Performance estimates are that the Iroquois will add 400-to-500 mph. to the aircraft's top speed and bring it to the Mach 3 speed range.

Possibility of ever proving whether the Arrow and its Iroquois engines could reach this speed free of serious trouble is now largely academic. It would be virtually impossible to continue a flight test program in such an early stage without large-scale engineering support which the government is not prepared to pay.

The government also indicates that it will not release that test data that has been collected thus far because, although no Western power is interested in either the engine or the airframe, it feels that the information possibly could aid a potential enemy.

Official reaction of the Royal Canadian Air Force to the cancellation of the CF-105 is lacking since in Canada advice from the military is rarely made public except through the civilian members of the government.

However, Air Marshal Roy Slemon, RCAF deputy commander of the North American Air Defense Command, made his support of the CF-105 public last November and was severely reprimanded in Ottawa. Slemon said:

"We would be derelict in our duty not to make recommendations in which we seriously believe. . . . If I have gone beyond propriety, I'm quite prepared to suffer the consequences because I believe I must be quite frank."

In discussing the CF-105's performance, Prime Minister Diefenbaker referred to another published report that the fighter's combat radius was only about 500 mi. He said that such a range did not warrant calling the aircraft a long-range jet fighter as it had been represented to the Canadian people.

Diefenbaker also said that the Arrow could not enter general squadron service until 1962 when long-range ballistic missiles would represent the primary threat to North America.

According to government estimates, Arrow expenditures in some years of its development and production schedule would have come close to 10% of the over-all defense budget.

Diefenbaker said that "the cost of the Bomarc missile to Canada, as compared to the $781 million for the CF-105, is approximately $110.8 million. That represents something that must be taken into consideration, all things being equal and the defensive properties of each are about the same."

Political thought in Canada now seems to range from a great fear that Canada will lose its sovereignty if it does not have the technical capability to develop advanced weapons and does not pay completely for its own defense to beliefs at the other end of the scale that, if the U. S. will not share equitably in defense production, Canada should withdraw gradually from the North American defense picture and let the U. S. carry the burden alone.

Holders of the latter view point to the fact that U. S. troops have been stationed in European countries for years, with the U. S. paying a large share of the defense costs, and that none of these countries has lost its sovereignty. They add that savings to Canada incurred by throwing most of the burden of defense to the U. S. could then be expended on the economic development of the country.

Diefenbaker and most of his opposition are pursuing a course falling be-

Intelligence Schism

Ottawa—Variance in Canadian government's interpretation of intelligence on the Soviet bomber potential and that of the U. S. government, apparently from the same information, became apparent during House of Commons debate on the cancellation of Mach 3 Avro CF-105 interceptor. Minister of National Defense G. R. Pearkes said:

"All of the information we can get from the sources available to the government indicates that the threat of the manned bomber against this country is diminishing."

At another point, Pearkes told Commons that "the indication has been that the Russians are not continuing the production of any type of bomber more advanced than that known by the code names of the Bear and the Bison, and that the number of Bear and Bison aircraft in the Russian inventory is extremely limited and, furthermore, that these are the only two types of Soviet bomber which could reach this country and return again."

The Defense Minister also challenged a statement by an opposition member of Parliament that military observers recently said that the Russians in the mid-1960s would still have an inventory of 1,000 to 2,000 bombers capable of striking Canada in addition to its inventory of intercontinental ballistic missiles.

Pearkes replied that the statement "must not be taken as indicating that these 2,000 bombers could reach this continent or that more than a small fraction of that number could even make the return flight even if they were unopposed."

U. S. military intelligence has reported that the Russians now have under development a supersonic bomber code named the Bounder. While USAF in 1957 revised downward its estimates of Soviet production of the Bison jet bomber after it became evident to the Russians that the aircraft would have difficulty in performing an intercontinental mission, there has been little serious suggestion that the manned bomber threat has diminished. Development of the Bounder apparently was designed to provide an effective replacement for the Bison.

Details and initial test flights of a prototype of a Soviet nuclear-powered aircraft were first reported by Aviation Week in an exclusive story last Dec. 1, (p. 27).

tween these two extreme views.

Anti-American feeling is being expressed in some quarters because USAF failed to show any positive interest in the Arrow program and several other Canadian projects with acknowledged merit. Thus far, however, no strong sentiment has developed, and most judgment probably will be reserved until the outcome of U.S. and Canadian production sharing efforts become clear.

Public exchange between the government and A. V. Roe was bitter after the contract terminations. It included:

- **A. V. Roe** said it had no advance warning of termination. The government said just as strongly that the handwriting was on the wall for all to see.
- **Diefenbaker said** company management had discharged all its workers in an effort to embarrass the government. Avro said it had to discharge everyone and then rehire according to seniority to abide by union agreements. The combined Avro-Orenda payroll was around $1 million a week at their employment levels of two weeks ago.
- **Diefenbaker spoke at length** in Commons about the Avro "lobby" and the severe pressure the company purportedly brought to bear in an effort to save the Arrow.
- **Government said the company** had failed to propose any serious plans for alternative work if the Arrow were canceled. The company replied that it had made six proposals which no one in the government would discuss.

Degree of misunderstanding existing was illustrated when the Prime Minister discussed a company proposal for a small turbojet transport to replace the Viscount. Diefenbaker said that the company had wanted $30 million just to get the program under way. A company official stated that the offer to the government had been to risk considerable Avro funds in the development. He said its proposal had been to get a guarantee from the RCAF for the purchase of 25 of the aircraft. The sales price would be adjusted so that development costs would be amortized for a production of 100 aircraft and the company would have the responsibility for selling the rest.

Two meetings were held early last week between Diefenbaker and the A. V. Roe management. No statements were issued after the meetings except government assurances that means were being explored to find employment for the Avro and Orenda workers.

Douglas Sets Sales Record; Profits Drop

Santa Monica, Calif.—Douglas Aircraft Co. sales in 1958 reached a record high of $1,210,454,621, but net earnings dropped to $16,847,028, or $13,818,224 less than the company earned in 1957.

Company officers told stockholders the drop in earnings resulted from write-offs totaling $67.7 million on the DC-8 turbojet transport program; fewer deliveries of DC-6 and DC-7 propeller-driven transports; a protested renegotiation payment to the federal government of $2,025,000, and increasing labor and materials costs.

Douglas missile business increased 109% over the previous year, with sales of $415.6 million, compared with $199.1 million in 1957.

Military aircraft sales were $536.8 million.

At the close of the fiscal year (Nov. 30), the company employed 72,000 workers, down 4,000 from a similar period in the previous year. Company said a further reduction in work forces will be made in 1959, adding "this decline might be considerably greater than that in 1958, according to estimates based on present firm orders and letters of intent."

Discoverer Aborted

Vandenberg AFB—Second U.S. attempt to launch into a polar orbit its first Discoverer satellite vehicle was scrubbed last Wednesday only a few seconds before launch time. The abort came after more then four hours of "holds" of the fully fueled rocket. Although no official description of the technical difficulties encountered has been forthcoming, the abort may have resulted from valve freezing caused by the liquid oxygen used in the Thor first stage during the long delay.

A previous attempt to launch the Discoverer last Jan. 21 was canceled as a result of an inadvertent error by pad personnel when the Ullage rocket used to clear the starting turbopump of cavitation was fired by mistake. When the inhibited fuming red nitric acid was dumped for safety reasons, some seeped into the first stage Thor rocket. Ullage rocket is in the Bell Hustler second stage.

News Digest

Second Air Force-Martin Titan intercontinental ballistic missile was successfully test fired last week from Cape Canaveral, Fla., over a 250-300 mi. range in the second checkout of first stage-propulsion, guidance, structural integrity, etc. Dummy second stage was used. Four missiles originally were scheduled in this test phase, but two successful flights might cause a telescoping of this part of the program.

Contracts totaling $1.9 million for 30 sounding rockets to be fired from Wallops Island, Va., and Ft. Churchill, Can., in 1959 and the first half of 1960 have been awarded to Naval Research Laboratory by the Space Sciences Division of National Aeronautics and Space Administration. The division also has contracted with NRL for $2 million worth of instrumentation on 15 satellites and space probes that are to be fired this year and next. Instruments will measure moon's magnetic field, micrometeorite impact, cosmic radiation, etc. NASA has awarded Daniel, Mann, Johnson & Mendenhall, architects and engineers of Los Angeles, a contract for design of two launch emplacements, a blockhouse, and a static test facility at Wallops Island. Cost is estimated at $2 million. Launch emplacements may be used to launch both liquid and solid propelled research vehicles.

Thiokol Chemical Corp. directors last week voted in favor of a 3-for-1 split in outstanding capital stock, subject to stockholder approval on April 16. Split will be for stockholders of record April 20.

Convair Astronautics Division of General Dynamics Corp. has awarded a $3.1 million contract for Atlas intercontinental missile ground support equipment to Systems Division of Consolidated Electrodynamics Corp. Equipment includes high pressure helium and nitrogen control systems used for checkout of Atlas pneumatic and fuel systems prior to firing.

Grand Rapids Division of Lear, Inc., has received a $3 million follow-on order for coordinate converter systems for Boeing Bomarc IM-99A missile. System provides basic gyro reference and airborne computer for flight guidance.

Study contract in the field of anti-missile defense has been awarded to Solar Aircraft Co., San Diego, Calif., to be administered by Army Ordnance Missile Command. Contract was awarded as result of a new approach developed by Solar and proposed to Advanced Research Projects Agency.

Riddle Airlines last week signed a provisional order for four Armstrong Whitworth 650 turboprop cargo carriers as an eventual replacement for its present fleet of 32 low-capacity, high-operational-cost C-46s (AW Feb. 16, p. 35). Informed sources said the aircraft will sell for $1.5 million each. Terms to the carrier reportedly include 10% down and no payments until the second year, with the total purchase price expected to be spread over a six-year period.

WEST COAST AIRLINES is operating six turboprop Fairchild F-27s like the one above, along with a fleet of 14 Douglas DC-3s.

F-27s Boost West Coast Revenue Miles

In first three months' operation turboprop aircraft increase revenue miles flown; draw new customers.

By William S. Reed

Seattle—Introduction of turbine equipment by West Coast Airlines has in the carrier's three months' experience with the aircraft increased the number of revenue miles flown, attracted new customers and brought about a general expansion of business.

West Coast inaugurated its 40-passenger Fairchild F-27 service September, 1958, and produced some surprising figures for October, the first month of operation. During September, 1958, operation on certain selected routes, Douglas DC-3s carried 565 passengers per mile. During the first full month of F-27 operation, the same routes yielded 840.5 passengers per mile, an increase of 48.76%. In passenger miles, the increase was from 1,061,240 to 1,576,778.

Increase resulted despite the normal seasonal decline in business experienced every fall since the airline started. West Coast said the first increase in business might have been due to the novelty of the F-27 and the fact that passengers might have deliberately rearranged their schedules to try the new aircraft. However, the trend continued and year-end figures show that, for December, West Coast's six F-27s flew 2,275,641 passenger miles.

Figures for actual cost per seat mile were not available since the company had too many intangibles to consider for an accurate picture to emerge. Learning curve for all types of personnel from baggage handlers to management is still on the upswing and the sixth and last F-27 was not delivered until late November. West Coast's management believes, however, that the cost per seat mile will be favorable enough that, barring a general decline in the nation's economy, its end to government subsidy could come in three years if the F-27 were operated exclusively.

West Coast Airlines now operates its fleet of six Fairchild F-27s and 14 DC-3s over a route of 2,200 mi., making some 30 stops. Recently Civil Aeronautics Board tentatively authorized an additional 1,600 mi. of route with 14 added stops. Average stage length is about 68 mi., with shortest length 28 mi., and longest 204 mi. Ideal stage length computed for the F-27 operation is about 125 mi., but this cannot be achieved unless skip-stop authority is granted by the CAB.

This doesn't mean West Coast would discontinue service to small communities, but rather that aircraft would not stop at every station on every flight, thereby increasing the average stage length to more nearly approximate the optimum. One run West Coast pilots make around the state of Washington involves 16 stops. As a result, crews become very practiced in instrument approaches, landings and takeoffs, but stage lengths involved are not ideal.

Company Financing

West Coast has had financial uncertainties like most local service carriers, but its president, Nick Bez, through other business resources, was able to give considerably more enhanced credit standing to the line.

Once the decision was made to re-equip, West Coast obtained two $2 million bank loans, one from a Texas

bank. An additional $750,000 was raised by disposal of surplus assets and subscription to stock by company officials. Thus, West Coast is still in the position to avail itself of a Civil Aeronautics Board guaranteed loan, should it become desirable to refinance and raise additional capital. Although $4.75 million was more than needed for purchase of six aircraft, capital was needed for purchase of training aids and anticipated expansion of routes.

Although new aircraft have been in service too short a time to provide any definitive figures, company management is confident that the F-27s will be good revenue producers. West Coast sees the airplane as a means for getting the local service lines off subsidy.

F-27 Maintenance

Few bugs have shown up in the F-27, according to West Coast. Trouble involved O-ring failure in fuel pump, repeated inverter failure, and nose wheel retracting cable breakage. Fuel pump and inverter troubles were eliminated by fixes from manufacturers and nose wheel retracting cable breakage was stopped when gear-down limit speed was temporarily lowered from 170 kt. to 140 kt. Fairchild Airplane & Engine Co. is developing fixes on nose wheel cable breakage. Modification programs are already under way in which Fairchild will send teams with various kits to each user's base and perform work at inspection intervals.

Another modification which affects the first five aircraft delivered to West Coast is the cabin air conditioning blower. In flight, the blower makes an objectionable, high-pitched whine. This was eliminated in West Coast's sixth airplane but modification in the field will be necessary for the first five.

Still another difficulty appeared in the pneumatic system which operates the landing gear, nose wheel steering, passenger entrance door and the wheel, parking and propeller brakes. Moisture would collect around the pressure relief valve in the system during operation in the relatively warm humid climate around Seattle. East of the Rocky Mountains, the dryer, colder climate caused the valve to freeze. This caused no emergencies, but did necessitate fixes to the valve and dehumidifying aspect of the engine driven compressors.

WEST COAST'S average stage length is about 68 mi. Shortest is 28 mi.; longest is 204 mi.

One of the Rolls-Royce Dart 6 turboprop engines on the oldest F-27 was removed after a total of approximately 700 hr. airframe-engine time. Removal was premature, not due to failure, but done so that regularly scheduled engine removals for overhaul work could be staggered. Rolls-Royce reported back to West Coast from its Canadian facility that the engine showed nothing more than routine wear.

Baggage Bays

One other minor engineering change contemplated by West Coast is modification of baggage bays. Baggage now is carried in two large bays forward of passenger cabin. These are ideally located, according to West Coast, but must be subdivided. Anticipated fix is to install a shelf in each bay so that baggage need not be loaded in stacks. Because of short hauls, it has frequently been necessary to off-load baggage to get at pieces which are on the bottom of the pile. Installing shelves, a simple matter, will eliminate stacking.

Some of West Coast's pilots were practically weaned on the DC-3 and, as such, viewed the new F-27 with a some-

Comparison of Selected Flights

(Including extra sections)

		Total Passengers Per Mile F-27	DC-3	Percentage Increase
(496 mi.)	Seattle to Klamath Falls	121.7	78.9	plus 54.25%
(352 mi.)	Portland to Klamath Falls	109.4	64.0	plus 70.94%
(496 mi.)	Klamath Falls to Seattle	123.7	85.5	plus 44.68%
(352 mi.)	Klamath Falls to Portland	76.7	67.5	plus 13.63%
(282 mi.)	Seattle to Lewiston	106.6	65.4	plus 63.00%
(746 mi.)	Seattle to Idaho Falls	147.1	99.5	plus 47.84%
(282 mi.)	Lewiston to Seattle	91.1	51.3	plus 77.58%
(746 mi.)	Idaho Falls to Lewiston	64.2	52.9	plus 21.36%
	Totals	840.5	565.0	plus 48.76%

Aircraft Comparative Operational Statistics

December, 1958

DC-3 Aircraft No.	Plane Days	Revenue Hr. Flown	Non-Rev. Hr. Flown	Total Flying Hr.	Avg. Daily Rev. Util. Hr.
101	31	112:57	13:10	126:07	3:39
102	31	132:43	1:23	134:06	4:17
103	31	120:02	3:46	123:48	3:52
104	31	000:00	0:00	000:00	0:00
105	31	132:32	3:31	136:03	4:16
106	31	164:04	1:16	165:20	5:18
107	31	116:20	2:13	118:33	3:45
108	31	116:28	:49	117:17	3:45
109	31	75:35	5:26	81:01	2:26
110	31	83:23	6:48	90:11	2:41
111	31	109:56	4:30	114:26	3:33
112	31	84:58	4:20	89:18	2:45
114	31	121:17	7:23	128:40	3:55
115	31	45:35	3:09	48:44	1:27
Total DC-3 for December, 1958	434	1415:50	57:44	1473:34	3:16
F-27 Aircraft No.					
701	31	173:18	13:49	187:07	5:36
702	31	145:29	1:54	147:23	4:41
703	31	200:42	5:51	206:33	6:28
704	31	159:30	11:13	170:43	5:09
705	31	157:52	5:09	163:01	5:06
706	16	18:24	40:25	58:49	1:09
Total F-27 for December, 1958	171	855:15	78:21	933:36	5:00
F-27 for entire year to Dec. 31, '58	463	2107:51	238:13	2346:04	4:33

what jaundiced eye. However, once transition to the new equipment was completed, they were won over. They are unanimously enthusiastic when talking about the aircraft. Yo-yo operation of West Coast's routes made for a hard day in the "front office" but fatigue factors are considerably reduced in F-27. Copilots work a bit harder because the same amount of paper work and reporting by radio has to be done as in the DC-3, but in a shorter time.

Considerable operation on wet and icy runways is necessary on some stations and this is easier in F-27 than in DC-3 types. F-27s are not equipped with thrust reversers, but placing the propellers in flat pitch produces very good braking effect. Landing at Seattle's Boeing Field on a wet runway in a no-wind condition, the F-27 needed power application to turn off at halfway point. This was accomplished without use of brakes.

Training for conversion to F-27s costs West Coast about $3,900 per crew. Included is cost of somewhere between 11 and 20 hr. of flying time, 100 hr. of ground school, and crew salaries. Complete training kit on the Dart engine-propeller combination was purchased from Rolls-Royce, in addition to manuals from Fairchild on the airframe. Training will continue until all of West Coast's 26 crews are transitioned; thereafter they will get periodic refresher courses.

Airline also has had to hire about 68 additional ground personnel as a result of increased business. Baggage handling and ticketing operations, all predicated on the 24-passenger DC-3, had to be expanded, as well as the reservations staff. Additional personnel will be added when new routes go into effect.

One facet of F-27 operation is causing West Coast considerable concern, and this is where CAB Special Regulation 422A restricts the aircraft's takeoff gross weight. SR 422A is applicable to all turbine-powered aircraft and makes no distinction between turbojets and turboprops. Thus, turboprops must pay the same penalty as turbojets, even though they do not suffer as great a thrust loss when operating at elevated temperatures. Turboprops suffer a greater loss of efficiency at elevated temperatures than do reciprocating-engined aircraft but not as much as turbojets.

Even though the F-27 at full takeoff gross weight and with full temperature accountability has a better single engine performance than a DC-3, passenger loads must be restricted at some stations when runway temperatures reach 87F. It is the second segment climb gradient portion of SR 422A that hurts the F-27 and West Coast hopes the CAB will take cognizance of the difference between turbojet and turboprop performance and make adjustments in the regulations.

Generally, West Coast's management feels that things are definitely looking up for the local service airlines. Trunk lines, once dedicated to stamping out smaller lines, are now extending cooperation. Now that an aircraft built to permit economical operation or short hauls is available, trunk carriers realize the value of feeders and have given up routes which they have not been able to operate with their larger equipment. Local service carriers also appear to be headed for daylight out of the financial woods and expect to find a place as a permanent part of the nation's economy.

Malayan Considered In Hong Kong Merger

Hong Kong—Merging of Hong Kong may be followed by merger of Malayan Airways and Cathay Pacific Airways Airways with the new combine, reliable sources here believe. Negotiations are reported under way.

In effect, Cathay Pacific is taking over Hong Kong Airways' routes. Hong Kong has operated under heavy losses for the past two-and-one half years; sources said British Overseas Airways Corp., a half-owner, was prepared to support the losses, but the other owner, Jardine, Matheson & Co., Ltd., was not.

BOAC will continue to have a minority interest in the new company and a member of Jardine, Matheson will hold a seat on the board of directors. Cathay Pacific is principally owned by Butterfield and Swire.

Cathay Pacific was originally organized by three ex-U.S. military pilots in Burma and southwestern China after World War II. Butterfield and Swire bought the airline in the early postwar period and expanded its routes toward the south in the hope of carrying a great part of the Chinese emigrant traffic which Hong Kong Airways, flying north out of Hong Kong, was to have picked up in mainland China. The fall of China to the Communists in 1949 brought a halt to traffic in and out of China of any volume. But the great increase in air travel through the area has made the airline a very profitable venture.

Cathay Pacific has had no grandiose ideas, runs a very tight, small organization. The economies of Butterfield

and Swire's long years in China trade have been transferred to the airline and no unnecessary expenses are allowed. For example, Cathay Pacific, while respecting International Air Transport Assn. fares, has never joined.

The line operates out of Hong Kong to Manila, British Borneo points, Singapore, Malaya, Laos, South Vietnam, Cambodia, Thailand, Burma, and into Calcutta in India. It has rights to Indonesia and Australia but has never exercised either. (Australia National Airways is one of the five stockholders in the company but control of the old Cathay Pacific was completely in the hands of Butterfield and Swire, as will be the new company.) With the merger, it now picks up Hong Kong Airways' routes to Manila, Taipeh, Tokyo, and Korea.

Last year the airline carried 58,807 passengers as compared with 48,970 the year before, and 47,438 in 1956. The load factor over all routes for the year was 60%.

Malayan Airways, which recently had to abandon its Singapore-Kuala Lumpur Hong Kong flights, is a combination of local capital and BOAC and would fit neatly into the new Cathay Pacific-Hong Kong package.

Such a regional carrier will find an increasingly big role in this area with BOAC planning to begin Comet flights into Hong Kong through India shortly and Pan American hoping to get transpacific jets operating before the end of the year.

National Plans Route Pattern Expansion

By L. L. Doty

Miami—Sparked by its successes with Boeing 707-120 turbojet operations, National Airlines is keying its future plans for jet service to an all-out drive for an expanded route pattern that will provide high-density industrial markets as counter-balances to its seasonal Florida traffic.

The carrier's current re-equipment program is designed to meet the needs of the fluctuating New York-Florida market while providing long-haul and short-haul flexibility in serving such a market as a southern transcontinental route. National hopes to add this latter route to its system as an ideal offset to the vagaries typical of resort traffic.

Here is National's future equipment program as outlined to AVIATION WEEK by L. W. Dymond, vice president-operations:

- **Reciprocal lease agreement** with Pan American World Airways will provide National with either the Boeing 707-120 or Douglas DC-8 turbojet service it needs to cover the busy five-month Florida season from December to April. Period of the lease is 10 years (AW Sept. 15, p. 38).
- **Fleet of three Douglas DC-8** turbojets, scheduled for delivery next January, will fill the carrier's initial long-haul needs. Total of 23 Lockheed Electra turboprops with delivery beginning in April, will serve the off-season Florida market and cover all medium-haul operations throughout the present and planned route structure.
- **National will retain its fleet** of Douglas DC-7s to supplement the Electra operations. Serious consideration is being given to the conversion of the DC-7s to turboprop power.
- **Carrier plans to dispose of** its 12 Convair 340s once the modernized fleet is fully integrated into the system. Convair 440s and DC-6s probably will be retained to handle short-haul requirements.

To date, experience with the Boeing 707-120 operated under a short-term lease with Pan American has proved to be a "spectacular" success, according to National officials. Load factor has held consistently at a strong 92%. Only two flights have landed short of destination since service began Dec. 15—one flight was canceled at Philadelphia because of weather at Idlewild and another flight was interrupted at Baltimore for mechanical reasons, calling for an unscheduled engine change.

According to Walter Sternberg, senior vice president-traffic, sales and public relations, the Boeing is attracting passengers because its flight characteristics are mitigating the fear element of flying. Sternberg told AVIATION WEEK that National's experience with the Boeing all but contradicts earlier surveys of jet flight which generally suggested that the fear factor might climb with the introduction of turbojets. He said the lower noise level and lack of vibration appear to be creating a greater sense of security among passengers than is normally evident on piston engine flights.

Ground Handling

The airline has encountered no serious ground-handling problems with the Boeing, according to Dymond. Loading and unloading the Boeing's full capacity of 115 passengers has not posed any abnormal difficulties since the airline was already equipped to handle the 104 passengers which the coach version of the Lockheed 1049H Constellation now carries.

Sufficient gate space is available at both New York International Airport and the new Miami International Airport to permit the Boeing to stand by at its gate position while waiting for a takeoff turn during airport ground delays. At airports where gate space is at a premium and parking time is limited to as short a spell as 30 min., turbojets will be required to hold at the end of runways with power on during takeoff delays.

National has entered the 120 into holding stacks and held to established traffic patterns without suffering too severe economic penalties or requiring special operating privileges. However, the carrier is actively pushing for the early use of separate holding stacks and let-down procedures of turbojet aircraft.

Dymond said turnaround procedures at Miami are scheduled at one hour and 15 min. Turnarounds, which include cabin cleaning, ground maintenance and refueling, are normally completed well under the established time, although cleaning crews have been increased in size because of the difficulty in cleaning the light colored fabrics Pan American has chosen for the interior. National does no airframe or engine overhaul work on the Boeings.

Sternberg has admitted that a number of complaints against the three-abreast seating configuration of the Pan American Boeing have been received. The aircraft is designed with a North Atlantic economy-class, three-abreast seating compartment with a first-class section and an eight-seat passenger lounge.

All seats are sold at first-class rates but the first-class, two-abreast seats and four of the lounge seats carry a $10 jet surcharge. Federal Aviation Agency is checking safety regulations to determine whether passengers can be seated in lounge areas which may not provide sufficient back support during landings and takeoffs.

Sternberg has handled all complaints individually by a letter explaining that National's desire to accelerate the introduction of turbojet service on the New York-Miami route prompted the carrier to use the Pan American Boeings at first-class fares despite a seating arrangement which is unconventional in domestic operations.

Pamphlets explaining the seating configuration in a similar vein are now distributed on all jet flights.

Sternberg has long been a strong supporter of coach service and is not an advocate of a substantial fare increase. In fact, National is the only U. S. trunkline which has not applied for a fare increase in the Civil Aeronautics Board General Passenger Fare Investigation.

He told AVIATION WEEK he would

like to see the elimination of the 10% government transportation tax with fares increased by that amount if the rates must be increased at all and added: "The relative position of the airlines in the transportation field grows stronger as our prices remain low while costs of rail, bus, automobile and even shoe leather continues to climb."

A. G. Hardy, senior vice president in Washington, later echoed this philosophy by noting that all carriers have empty seats each day and "it isn't going to be any easier to sell those empty seats by increasing the price of them."

Sternberg is not supporting lower fares. In fact, he does not necessarily endorse promotional types of fares but believes that the best way to generate new traffic and develop new markets is through dependability of service. He wants to see schedules operated with "subway regularity" as a major step toward building up both short-haul and long-haul commuter traffic—a market, he adds, that has been barely tapped.

Sternberg believes there is "no weather" in today's operations which should cause prolonged traffic delays. He anticipates that over-taxed airways should be eased sufficiently by 1963 to permit the regularity of operation he feels is necessary before airline seats can be merchandised effectively.

In addition, he prefers to see the development of such programs as "fly-drive" campaigns to pierce competition stemming from the private automobile rather than to employ promotional, cut-rate type fares to create new traffic.

National Airlines reported a net profit of $1,163,941 for the three months ended Dec. 31 compared to a $879,800 net loss incurred during the same period in 1957. An increase in operating revenues from $9.9 million during the last three months of 1957 to $18.6 million for the same period in 1958 is attributed to the 31 day strike that hit National in the fall of 1957 and the strike that grounded Eastern Air Lines late last year.

Total assets of the company as of Dec. 31 reached $74.7 million as compared with $59.9 million in 1957. The sharp rise is reflected in the investment and special funds item on the company's balance sheet. This item climbed from $7.4 million to $21.2 million as the result of the exchange of 400,000 shares of capital common stock with Pan American at a value of $22.50 a share.

Because of the resulting improved current asset position and a strong current asset-current liability ratio, National is in an excellent position to move into its re-equipment program without requiring further borrowings.

The airline has dropped its cash dividend program so that it can plow earnings back into the purchase of equipment. Other cash resources are available through depreciation and amortization which, during the six months ending Dec. 31, amounted to $4.1 million.

BOAC Far East Route Proposal Draws Protest of U.S. Carriers

Washington—Plans of British Overseas Airways Corp. to introduce turboprop service from New York and San Francisco to Honolulu and Tokyo are drawing bitter protests from the domestic airline industry.

Strong opposition to the BOAC move stems from an application by the carrier to the Civil Aeronautics Board for an amendment to its foreign air carrier permit to include Tokyo on its route from Hong Kong to San Francisco and New York. Operation of the new service—scheduled to begin April 1 if the Board approves the application—will close the final gap in BOAC's around-the-world route.

U. S. carriers, however, are not objecting specifically to the opening of BOAC's transpacific service but rather the proposed Tokyo stop. During the Board prehearing conference in the case last week, Northwest Airlines proposed that the foreign air carrier permit be granted but that the Tokyo stop be temporarily "severed" from the case for further study and consideration.

In addition, Northwest asked that temporary traffic restrictions on the New York-San Francisco sector of the route be included in the permit pending a Board decision in the Qantas Empire Airways cabotage case (AW May 19, p. 38). In this case, Qantas is seeking a legal interpretation as to whether it has the right to carry traffic which is destined or originating outside the U.S. between points within the U.S.

BOAC has opposed both proposals. The airline is contending that it has the right to serve Tokyo because of an exchange of notes between the U. S. and British delegations following the review of the bilateral pact between the two countries in March, 1957, and that supplemental agreements are involved.

U. S. carriers are holding that BOAC can add a new stop to its present route only through section 4B of the bilateral agreement which states, in effect, that either country may add intermediate stops to existing routes if the other country is so informed of the action.

However, both the U. S. and the United Kingdom have agreed in the past that "intermediate" point implies a "minor traffic" point. In this instance, U. S. carriers are charging that Tokyo, as the largest city in the world, is hardly a "minor" stop. In addition, the carriers claim that, since Tokyo is 1,300 mi. off BOAC's direct Far East route, it is hardly an "intermediate" point.

The British government upheld these views in a letter sent to the State Department on Jan. 22, 1957, by the civil air attache of the British Embassy here. The letter served notice of BOAC's intention of inaugurating the transpacific service and, at the same time, it reaffirmed its interpretation of section 4B to mean that an intermediate point is a "minor" traffic point.

The British, however, can now be expected to introduce the Pan American route between Tokyo and Hong Kong into the case. They will contend that this service was inaugurated in 1947 after notice was filed under section 4C —not 4B—of the bilaterial agreement. Section 4C calls for the periodic exchange of information between the two countries on routes and services, says nothing about additional stops.

Two years after the Pan American service began, the British did question Pan American's right to serve Hong Kong but made no move to stop the service. Northwest Airlines, which also is certificated by the U. S. government to serve Hong Kong, as is Pan American, has never received British permission to serve Hong Kong on a scheduled basis.

Conjecture throughout the industry is that the British government will contend that Tokyo should be granted BOAC as a stop on a reciprocal basis since Pan American is already serving Tokyo, a major traffic point on the latter's route.

As the case now stands, Northwest is the only intervenor in the proceedings. Last week the Air Transport Assn. petitioned for leave to intervene.

In its petition, the ATA noted that the BOAC application filed with the Board on Nov. 8 was not served on the ATA or on any U. S. flag carrier. It added that on Nov. 9 the Board set the application down for hearings to begin Nov. 19 and that notice to this effect was not published until Nov. 11.

This procedure, the petition said, allowed only 14 days between the hearings and the announcement of the hearings, making it impossible for any party to intervene since such petitions to intervene must be filed 15 days prior to hearing.

707 Drops Engine in Test Flight

By Robert H. Cook

Washington—Phase-in problems of the Boeing 707-120 mounted last week with the in-flight loss of a right outboard engine from a Pan American World Airways aircraft during a training mission north of Paris, France.

Loss of the engine came as the Civil Aeronautics Board pressed its three-week-old investigation of the 29,000 ft. dive taken by another of the airline's 707-120s on a Feb. 3 transatlantic flight (AW Feb. 9, p. 39). Tentative dates of Mar. 11 and 12 have been set by CAB for the taking of depositions from Pan American flight crew members and maintenance personnel at Idlewild Airport in New York; Mar. 26 for Boeing Aircraft inspection, testing and engineering teams in Seattle. Board spokesmen indicate official findings determining the probable cause of the dive may be made released within the next six weeks.

Investigation of the two incidents also left Pan American with only four 707s to cover its daily transatlantic service and provide aircraft under the lease arrangement with National Airlines between New York and Miami (see p. 31).

Boeing released the aircraft involved in the dive after a successful test flight. Pan American was scheduled to return it to service by the end of last week.

Substitute Aircraft

Loss of the second jet from transatlantic service after the engine loss was compensated for the same day by Pan American by placing a DC-7C and DC-6B on a parallel departure schedule from Paris. Recovery of its other jet from the manufacturer will allow the airline to cover its schedules for both the overseas flights and its jet lease arrangement with National Airlines on the New York-Miami route, said Pan American.

Jet training program for its pilots will be little affected since most of it has been conducted with layover time on European runs in London and Paris. Future jet training is expected to be conducted from Miami to utilize better weather conditions and layover time from National's jet schedules.

Loss of the engine on Pan American's training flight took place while two of the airline's captains were undergoing a check flight with a company check pilot, a flight engineer and a Federal Aviation Agency safety advisor. The crew included instructor pilot Capt. John W. Ryan; Captains John M. Mattis and Howard M. Cone; flight engineer Herbert C. Seilberger, and Hyram Broiles, FAA representative in Paris.

Company spokesmen say Capt. Ryan was demonstrating minimum control speeds at 8,000 ft. under the airline's prescribed training program when the 707 stalled at an estimated speed of 120 kt. and started into a right spin. The plane lost 2,000 ft. of altitude and the violence of the recovery maneuver tore the engine and pod mounting from the wing.

Recovery to normal flight speed and altitude was made with no difficulty, and the aircraft was flown to London where more complete maintenance facilities are available.

Fell in Pasture

FAA later reported that the engine was recovered in a pasture near the village of Pioneis on the Brest peninsula. Condition of the powerplant was not reported, but agency spokesmen expect their examination to settle any question of possible engine malfunction, such as possible turbine seizure, or whether the accident resulted from an airframe deficiency.

Although the investigation is in its early stages, with both CAB and FAA representatives in London and Paris, some FAA observers feel there may be some doubts on repeating this type maneuver which subjects the aircraft to unusual, and possibly unnecessary, structural strains. Final results of a formal investigation could possibly recommend both a strengthening of airframe components and a change in airline jet training maneuvers, according to FAA officials.

Boeing Aircraft Co. made no particular comment on the accident other than that its field representatives in London are working with Pan American on the case.

Civil Aeronautics Board has essentially completed a technical examination of autopilot components suspected of causing the Feb. 3 dive 500 mi. east of Gander, Newfoundland.

Results of the examination are still under study, and CAB also is searching for other operational clues to the accident, possibly recorded in the aircraft's LAS flight recorder manufactured by Lockheed Aircraft Service.

Seek Tracings

Although the recorder's tape was reported to have run out prior to the sudden dive, Board investigators are having Lockheed conduct a micro analysis of the instrument in the hopes of finding tracings on the component that will reveal the aircraft's exact altitude, attitude and flight maneuvers.

One of the unusual aftermaths arising from investigation of the abrupt maneuver was the discovery by Pan American that its impounded jet was significantly radioactive. Radiologists of the Department of Health, Education and Welfare were summoned by the airline after U. S. Customs agents in New York reported that company mechanics returning from an inspection of the aircraft in Gander had picked up a radio active count in their work gloves. Geiger counter also picked up readings from the mechanics' suitcases.

Spokesmen for the government department said readings on the grounded Boeing were not "significantly higher than allowable" but were higher than found on the remainder of the airline's jet fleet. Source of the contamination was not readily determined, but at least some of it was attributed to the jet's high altitude flying in a region nearer to cosmic rays. Aluminum structure of the aircraft provides adequate protection against this amount of radiation, they said.

Transpacific Case Ordered Reopened

Washington—White House, for the second time since 1956, has ordered Civil Aeronautics Board to reopen the controversial transpacific air route renewal case to reconsider Pan American World Airways' bid to fly the North Pacific route. On all previous occasions, the White House has reversed CAB recommendations.

CAB originally recommended that Pan American fly from the U. S. to Tokyo via the central Pacific and Northwest Orient Airlines from the U. S. to Tokyo via the North Pacific, both on a temporary basis.

In the 1954 renewal case, Pan American applied to serve the North Pacific route as well as the Central Pacific. This was turned down by the Board which stuck to its original recommendations, but White House approval was withheld and, in 1956, the Administration ordered the case reopened. Again the CAB's findings corresponded to its earlier recommendations. This time, the recommendations were approved by the White House, but one month later approval was withdrawn.

In requesting reopening of the case again, the President said: "I believe it is essential to foreign policy and administration objectives that the entire Pacific route complex be considered as a whole by the CAB. Accordingly, I am requesting the Board immediately to initiate proceedings to consolidate all Pacific air route matters in a single record and give me its recommendations at the earliest possible date."

AIRLINE OBSERVER

► Pan American World Airways and American Airlines are installing the conventional three-point altimeter on their Boeing 707 jet transports in addition to the drum-type altimeter already carried aboard the aircraft. Modification is the result of a Federal Aviation Agency order following a request by American for permission to make the change. Earlier, Eastern the American added the three-point altimeter to their Lockheed Electras in order to lift FAA operating restrictions on the turboprops (AW Feb. 16, p. 36).

► American Airlines gross passenger revenues increased 4.7% last year over 1958, but business fell 2.2% short of the carrier's established quota for the year. Air travel plan sales climbed 11%, military sales increased 4.3% and net government sales were up 8.5%.

► Russian air travelers are complaining that Aeroflot has inaugurated new local routes without adequate preparation. Flights often begin as soon as runways are ready but before communication systems, weather stations and passenger facilities are completed. As a result, trip cancellations are frequent, load factors drop as passengers turn back to surface transportation and the line loses money. Aeroflot admits that poor patronage stemming from unreliable service has forced the abandonment of several new routes.

► Boeing is now rolling a 707 turbojet transport off its Renton, Wash., final assembly line every three and a half days. Qantas Empire Airways' first long-range 707 was rolled off the line with the second Qantas 707 already moving into final assembly. American Airlines 12th and 13th 707 are just behind the first Qantas aircraft. British Overseas Airways Corp.'s first 707-420 powered by Rolls-Royce bypass engines is in No. 7 position on the current assembly line and scheduled for delivery in November.

► Lockheed Aircraft Service has delivered a Boeing 707 fueling system training panel to American Airlines for use in instructing maintenance and ground personnel in the fueling and defueling systems of the turbojet transport. Panel is electrically operated and reproduces the complete system as it appears on the aircraft.

► Russia is preparing to place its twin-rotor Yak-24 helicopter in commercial passenger service with an approved 30-seat cabin configuration. First exhibited at the 1955 Tushino Air Show, the Yak-24 has been thoroughly tested by Russia's military services.

► Pacific Air Lines will place the first of its six 44-passenger Fairchild F-27 turboprop transports into service in May on the high-density routes between Portland, Los Angeles and Las Vegas.

► Seaboard and Western Airlines is installing a cargo handler as a regular crew member on all daily transatlantic flights. Called loadmasters, the new crew members will be responsible for supervising loading and unloading, stowing and tie-down of cargo and weight and balance processes.

► Delta Air Lines is distributing throughout the company a jet planning schedule that details monthly progress in procurement, receipt, processing and checkout of all facilities, tooling, equipment, spares and parts for its fleet of Douglas DC-8 turbojet transports. The 25-page schedule is revised constantly, records work accomplished and target dates for future plans.

► Federal Aviation Agency will open a new dual airway system between Washington and Richmond to ease the present traffic bottleneck on routes to the south from Washington. New airways have been made possible by reduction in size plus the joint use of a restricted area over U. S. Navy Proving Ground at Dahlgren, Va., and joint use of restricted area over Army Camp A. P. Hill, Va.

SHORTLINES

► **Alitalia** will extend its routes on Mar. 4 to include Karachi and Bombay with two services each week from Rome. The flights, to be operated with Douglas DC-7C aircraft, will leave Rome Wednesdays and Saturdays for the Far East cities.

► **Continental Air Lines** flew an estimated 46,100,000 revenue passenger miles in January for a 44% increase over January, 1958. Airline also flew 1,516,000 revenue airplane miles, an increase of 21% over the 1958 figure. During the month, Continental flew 153,000 air freight ton-miles, up 8%; 100,000 air mail ton-miles, up 15%; 43,000 air express ton-miles, down 7%.

► **Flying Tiger Line** reports that net income and special items totaled $1,231,574 for the six months ending Dec. 31, were equal to $1.19 per common share on 1,035,284 outstanding common shares. Operating revenues for the first half of 1958 were $18,925,864 and operating expenses of $16,377,196 produced a net operating income of $2,548,668 before taxes.

► **Lake Central Airlines'** 1958 net profit totaled $83,950 as opposed to a net loss of $122,385 for 1957. Gross revenues for the year were $3,996,220, a 15.8% increase over 1957; operating expenses were $3,877,097, up 9.7%. Net operating profit for the year was $119,122, a $199,852 boost over 1957 when the carrier showed an operating loss of $80,950. Total revenue passenger miles flown in 1958 were 29,064,000, up 15.5% over 1957, and available seat miles increased 10.6% to 64,080,000. Over-all-passenger load factor figure for 1958 was 45.4% as compared with 43.5% in 1957. Lake Central also has purchased two additional Douglas DC-3 aircraft from Braniff Airways at an undisclosed price.

► **Lufthansa German Airlines** is scheduling its first transatlantic all cargo flights for Mar. 4 using the first of its newly acquired Lockheed Super-H Constellation air-freighter aircraft. Two round trip flights per week between New York and Frankfurt are planned.

► **Pakistan International Airlines** has received the first of five Vickers Viscount 815 aircraft on order and is flying the aircraft on the carrier's Karachi-Delhi-Karachi route.

► **Sabena Belgian World Airlines** carried a total of 954,630 passengers during 1958, a 39.1% increase over 1957.

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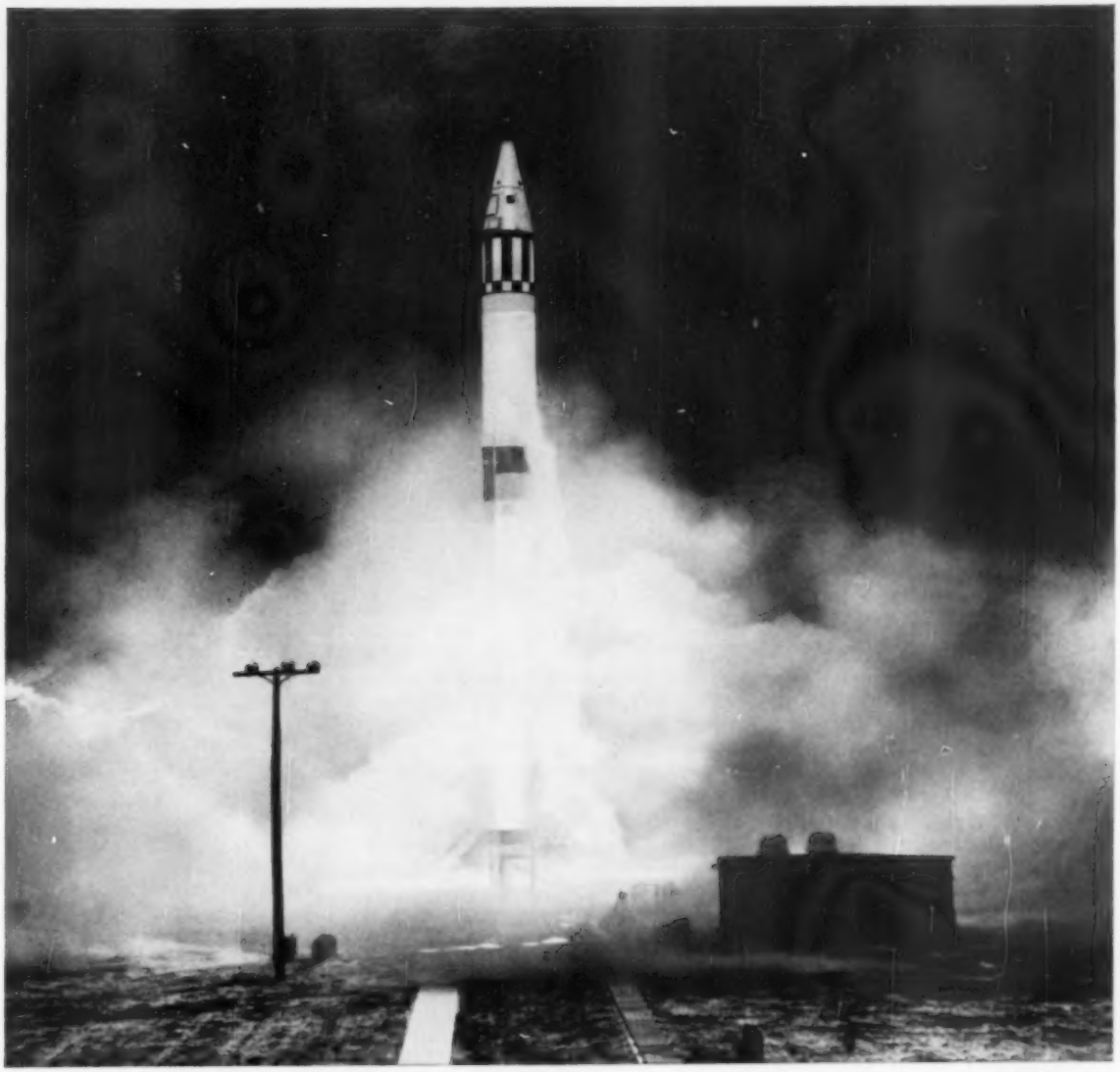
Missile makers tried it—and it worked! Now one of the big problems in missiles is solved—with the help of Timken® steel.

Whatever your steel problem, Timken Company metallurgists have a steel to solve it. And the skill to solve it economically. Why not give them a call? The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".



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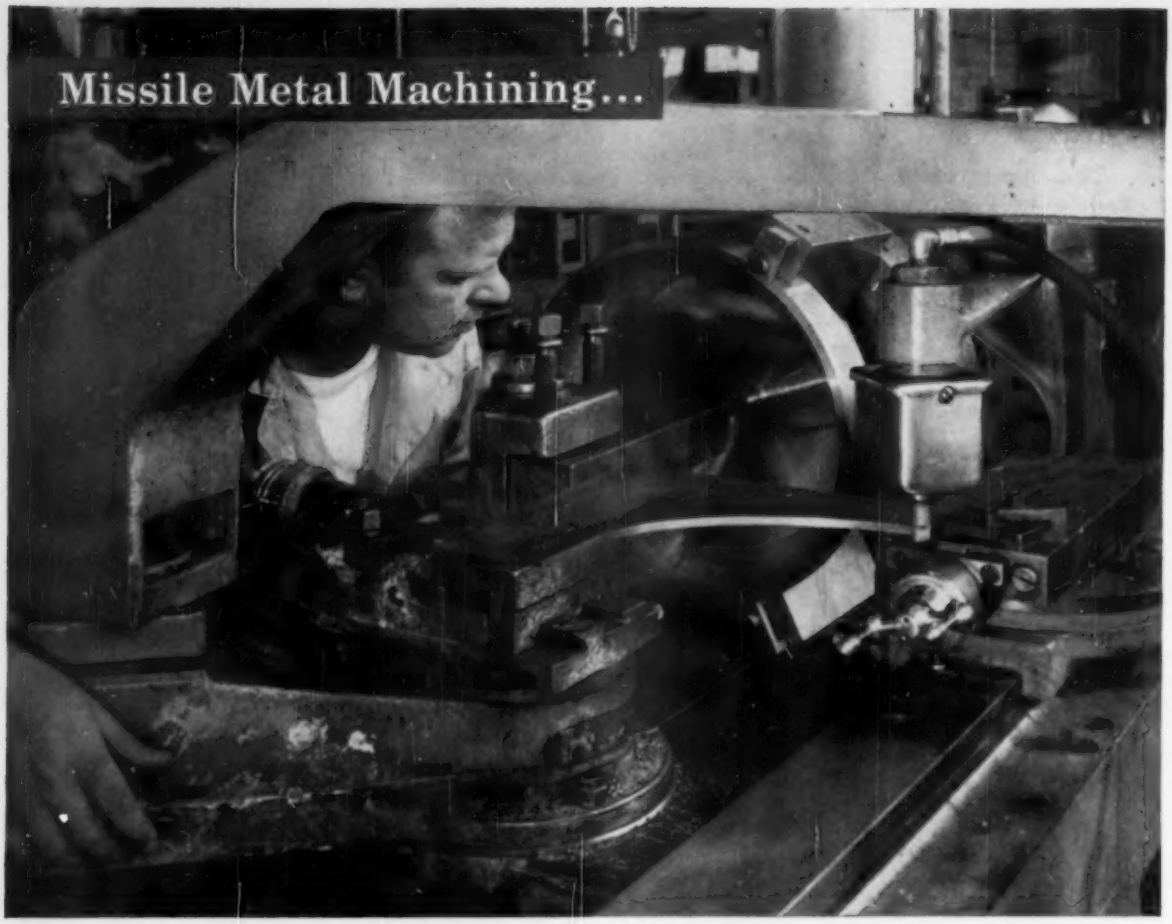

FROM BLANKS TO BULKHEADS!

The Diversey craftsmen above is machining the inner diameter of a Forward Bulkhead of the Hawk missile to a fine 63 microinch finish. Notice the precision curved template in the center of the picture with the follower at the right end transferring the contour to the interior of the bulkhead. Another good example of the famous air gage tracer lathe technique that has brought the missile hardware field to such an advanced state.

Diversey starts with blank forgings. Using their remarkable ability to integrate hydrospinning and contour turning techniques Diversey craftsmen are able to produce the finest and most precise missile and rocket hardware components.

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FROM NOSE TO NOZZLE, FROM FIN TO FIN, CONTOUR TURNED PARTS—WITH PRECISION BUILT IN

Short Brothers Designs Britannic As Low Cost Strategic Freighter

London—Low development costs, simplified spares and maintenance requirements and short flight and ground crew training periods are cited by Short Brothers & Harland as advantages of the Britannic strategic freighter ordered for the Royal Air Force (AW Feb. 16, p. 35).

Using the same wing, tailplane, undercarriage, flight deck and systems as the Bristol Britannia, but with a fuselage diameter nearly 50% larger, the freighter version will complement the Britannia 253 troop transport now going into service with RAF.

Fuselage of the Britannic has a diameter of 17.5 ft. and is 134 ft. providing a clear freight hold 12 ft. square over a forward 63 ft. section, and a sloping rear section 17 ft. high, reducing to 10.5 ft. Both the cross section and volume compare favorably with the Douglas C-124, Short says.

The Britannic is based on the Britannia 310 series and cruises at the same speed of 360 mph. Wing is unchanged with the exception of a six-foot larger span to meet the increase in gross weight from 185,000 lb. to 195,000 lb.

Maximum landing weight of 165,000 lb. is up 22%, but the undercarriage remains basically identical.

The fuselage is pressurized to 8 psi., and retains the same tail unit as the Britannia 310 but adopts a "beaver" door layout for in-flight dropping of large stores. The range with a 30,000 lb. payload is 5,500 mi.

Large radar trailers are listed among stores the aircraft can carry.

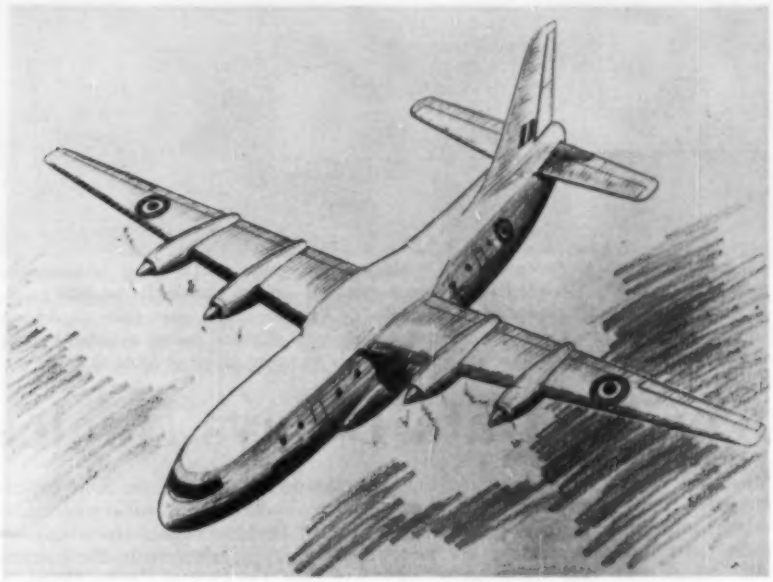
Normal accommodation of 140 troops can be increased to 200 by fitting a quickly detachable second floor at the forward end of the fuselage.

Short Brothers hopes to exploit the low cost, long distance civil freighting potential of the Britannic after 1963. As a passenger transport, the capacity payload over still air distances up to 2,600 mi. is 197 passengers.

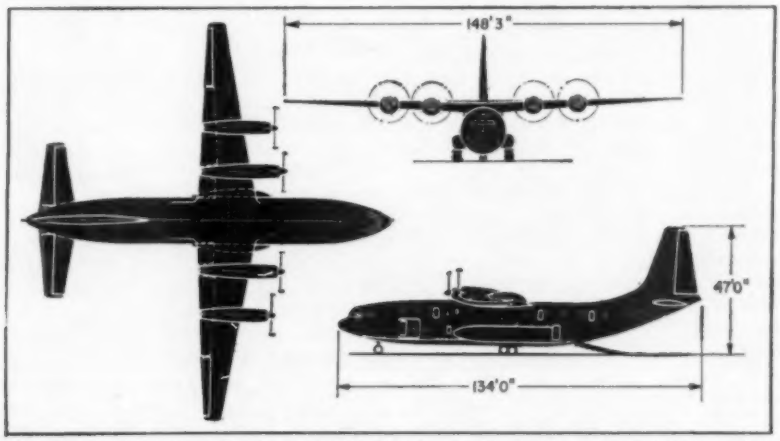
Floor of the main 60 ft. length of the freight compartment is flat and level. The rear 20 ft. ramp portion slopes and is used for loading as well as carrying freight. The ramp is positioned hydraulically.

Smaller freight is loaded in a side door 7½ ft. x 8½ ft. at the forward end of the hold.

A lashing grid can take up to 10,000 lb. point loads on the floor and 2,000 lb. loads on the walls. Special load points are provided for 25,000 and 35,000 lb. loads.



ARTIST'S conception of Short Brothers & Harland Britannic Mark 3 turboprop strategic freighter shows relationship to Britannia 310 configuration. Fuselage, however, is 17 ft. 6 in. longer (AW Feb. 16, p. 35). Company says Britannic can carry a maximum payload of 75,000 lb. at speed of 360 mph. for 1,400 mi. Aircraft, powered by four Rolls-Royce Tyne engines, has gross weight of 195,000 lb.



FUSELAGE of the Short Brothers & Harland Britannic has a diameter of 17.5 ft. and is 134 ft. long. Cross section and volume are comparable to that of the Douglas C-124.

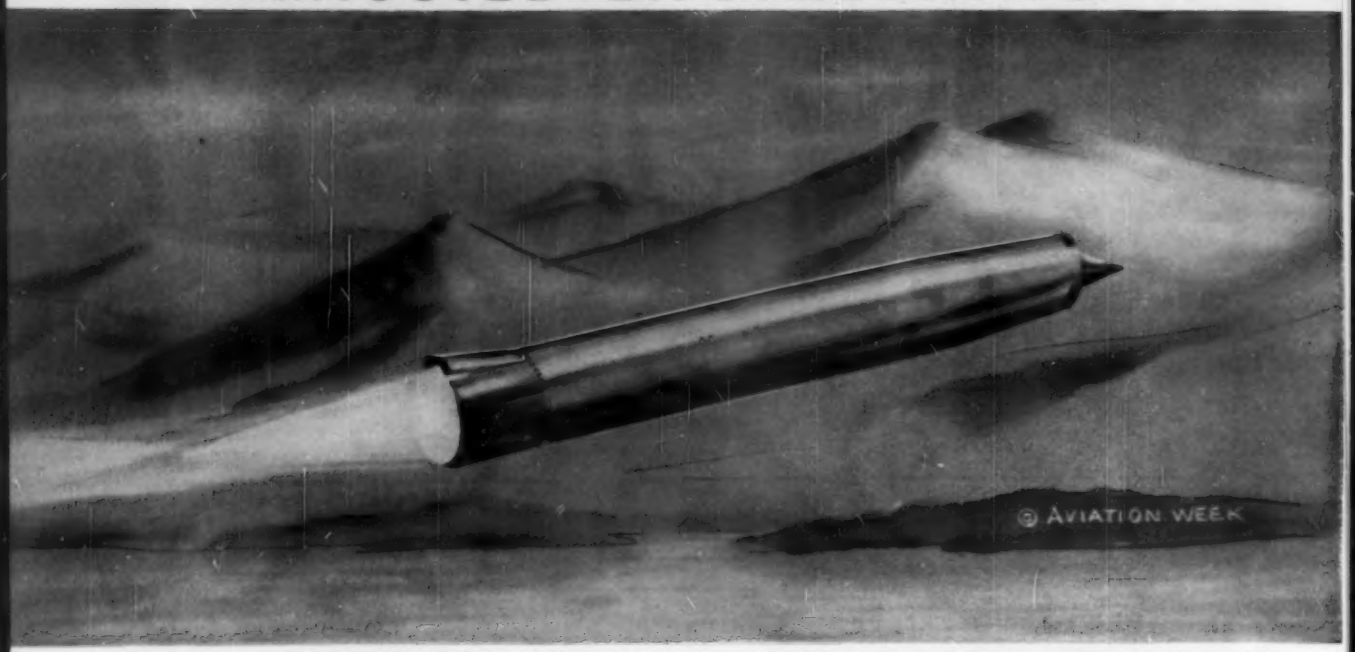
Morane-Saulnier Laying Off 600

Paris—Morane-Saulnier, unable to get backing for new projects, is now under government orders to close its prototype factory in the Paris area and lay off 600 workers.

Company probably will consolidate its operations at Tarbes, in the southwest of France, where it is building its four-place MS 760 twin-jet aircraft.

French aircraft industry currently is undergoing considerable difficulties as old orders are terminated and few new orders placed. The government reportedly is working on a new five-year plan which will give the industry a better idea of what is expected of it in the future. Industry observers are sure the plan will require considerable consolidation of present facilities, as well as liquidation of some companies.

Morane-Saulnier currently has an order from the French Air Force for 50 military versions of the MS 760. Argentine government also is buying and building another 48. The company also has sold about six of the civil version.



RAMJET weapon system with virtually unlimited range and a large payload which would use the nuclear reactor being developed by Project Pluto has been described to the Congress in some detail by Atomic Energy Commission and military personnel. An artist's conception of these descriptions is shown above. It would largely avoid ground-based detection by flying low and away from air defense systems which are currently concentrated along the few strategic attack routes which are possible with chemical fueled systems. Vehicle would probably be wingless for the shape shown has an adequate liftdrag ratio at the probable cruise speed range of Mach 2 to 4.

Lack of Engineering Data Delays Nuclear

By J. S. Butz, Jr.

Washington—A nuclear ramjet can be built with today's knowledge and technology.

"It is just a matter of do you want it or not," according to Dr. Theodore Merkle of the Atomic Energy Commission's Livermore Laboratory who has technical direction of Project Pluto, the U. S. nuclear ramjet program.

Present materials are adequate for use in all parts of a nuclear ramjet, and an operational supersonic vehicle can be constructed. This has been made clear in congressional testimony by Dr. Merkle and Air Force Col. Jack L. Armstrong, deputy chief of the Aircraft Reactors Branch of AEC's Division of Reactor Development.

The U. S. nuclear ramjet program, however, apparently is involved in a dilemma facing many U. S. development projects, which are said to be completely feasible and within the state-of-the-art by competent personnel who are working on them.

The money needed to go beyond the theoretical and laboratory test stages and build large scale test vehicles is delayed because concrete engineering data is not at hand to absolutely prove feasibility. Most engineers agree that feasibility can never be conclusively proven until the problems revealed by these large scale test vehicles are met and solved and that no amount of theoretical and laboratory work can circumvent the cost and time of engineering development.

Project Pluto is now in the midst of proving the feasibility of the nuclear ramjet.

Tory II is the first complete reactor that will be tested by Project Pluto. It is designed to prove, physics-wise, that a ramjet reactor can be built. Other reactors will follow Tory II to prove that the engineering of a full scale reactor for a ramjet can be successfully constructed.

The funding that has been available to conclusively prove feasibility has been extremely modest by any standards which might be applied today for low cost development work. In 1956, Curtiss-Wright and Atomics International received small AEC contracts to study the problems associated with nuclear ramjets. In 1957, the amount of money was greatly increased, and $4.6 million was made available for the program.

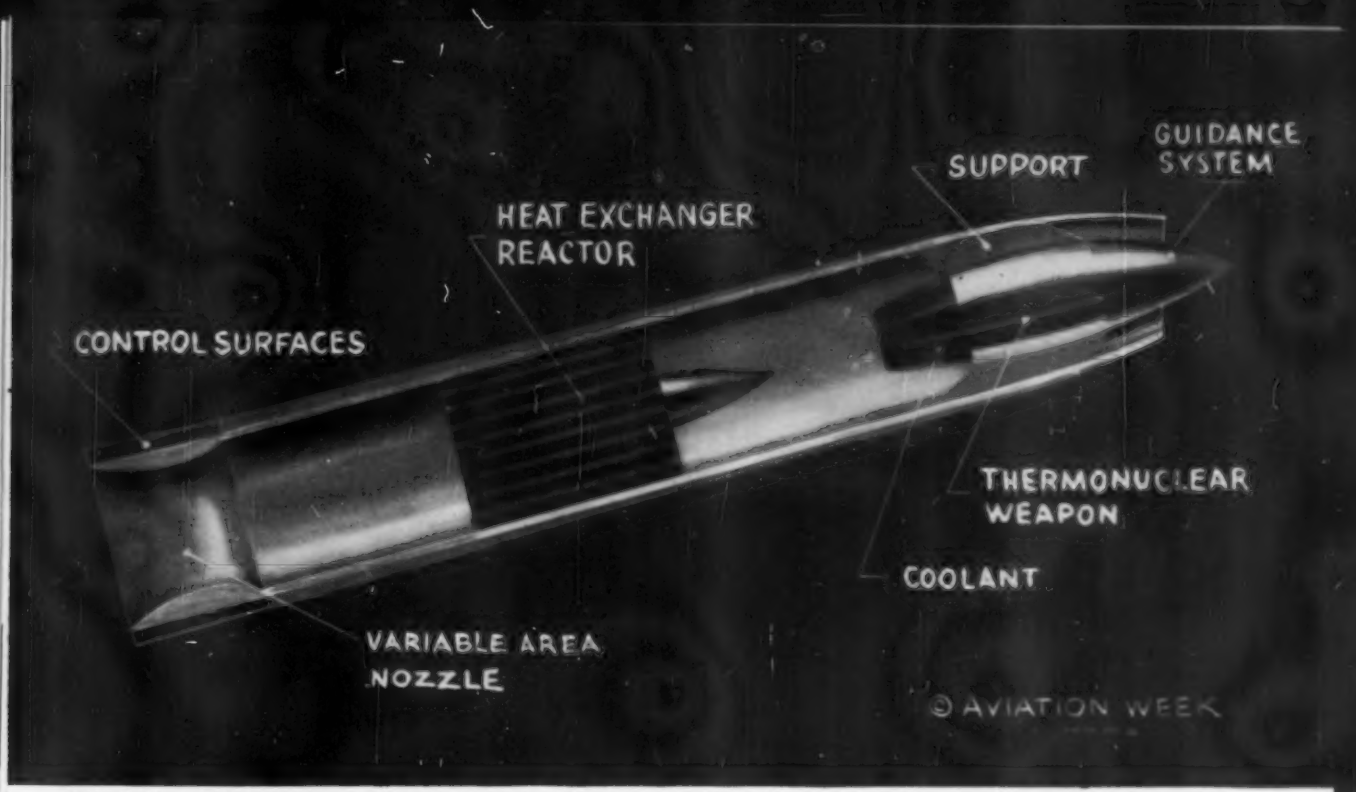
By that time, the project had progressed to the point where more expensive work was needed, and it was impossible to keep two contractors busy on separate approaches with the money available. The bulk of Curtiss-Wright's work was then terminated. It was financially possible, however, to have more people at the Livermore Laboratory transferred to Project Pluto because they could no longer be supported by Project Rover, the nuclear rocket program.

AEC Request

In 1958, the AEC requested $10 million in operating money for Project Pluto, but the request was cut in half by the Administration. An additional $2.5 million request for construction was allowed.

The AEC in 1959 requested only $5 million in operating funds for the project because its level of activity in 1958 had been such that it could not effectively use more money. Construction appropriations in 1959 were, as requested, $6.5 million.

Additional money was appropriated by Congress in 1958 and 1959 at the request of Project Pluto officials. The largest supplement approved was $3 million in Fiscal 1959.



GENERAL layout of the nuclear ramjet vehicle was outlined in congressional testimony. An artist's conception of this arrangement is shown above. Apparently the guidance system, thermonuclear weapon, coolant, pumps and other auxiliary equipment would be housed in the center body of the diffuser. The reactor would replace the combustion chamber in the chemical fuel ramjet. Four movable surfaces on the aft end of the wingless body would provide control. Some type of variable geometry air intake and exit nozzle systems would probably be provided to allow rapid altitude changes and maneuvering.

Ramjet

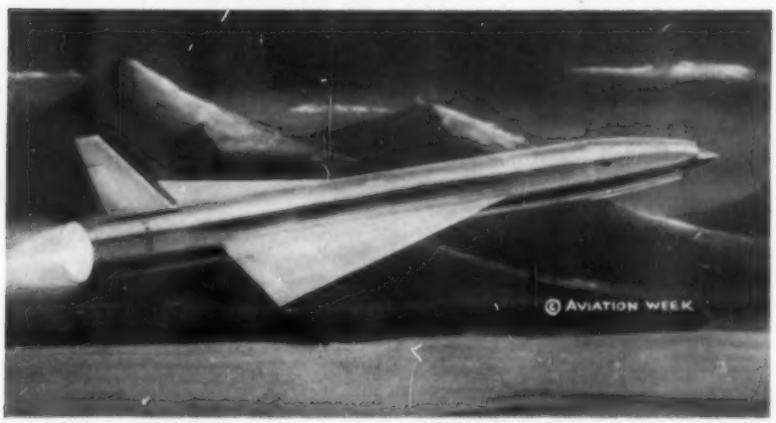
Dr. W. Kenneth Davis, director of the AEC's Reactor Development Division, gave an insight during congressional hearings into the methods used to determine the amount of money the Administration will allow for AEC programs. Dr. Davis said:

"Under various instructions from the Bureau of the Budget and after reviews by the commission we were, in effect, told that we should keep this program (Project Pluto) at the same level in Fiscal 1959 as it was in '58."

Dr. Davis also said that the budget for the entire commission was held to a specified level by the Administration with instructions that this figure would not be raised unless some compelling reason was proven for increasing it. He also indicated that the advice of the people in charge of each project was taken into account when the AEC divided the funds allowed it by the Budget Bureau.

However, Dr. Davis added, "In this particular instance (Project Pluto), it is true that the amount of money which we were finally able to put into this was not equal to what the laboratories thought they could do."

AEC funds are only part of those that are being expended towards producing a workable nuclear ramjet vehicle. Air Force is conducting programs to provide diffusers and nozzles that would be necessary to make a complete weapon system using the reactor AEC is developing. All of the nuclear work, including the very critical effects of radiation and high temperature on materials, is covered by the AEC appropriations.

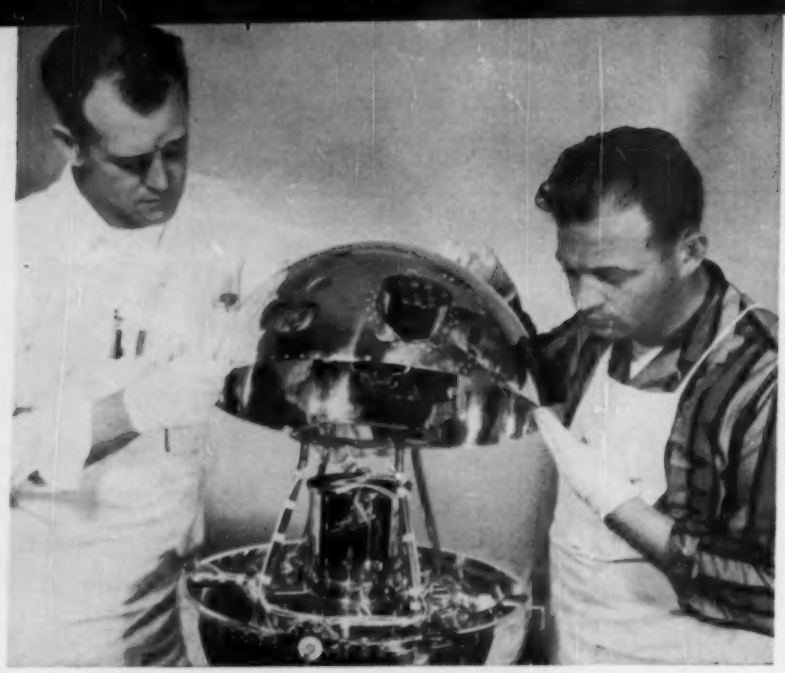


WINGED version of the nuclear ramjet might be desirable for certain mission requirements. However, at most Mach numbers liftdrag ratios on modified conical bodies such as this one are high enough to allow a large payload to be carried and provide adequate maneuvering capability. High maneuvering requirements around Mach 2 might necessitate wings but they would increase the cooling problem at higher speeds.

Operational Vehicle

The operational vehicle that would result from this effort by Project Pluto and the Air Force has been described at length by several military officers and project officials. Air Force Gen. Donald J. Keirn, chief of the Aircraft Reactors Branch of AEC's Reactor Development Division, has discussed the nuclear ramjet vehicle in the following terms:

• **It would have the highest** payload to gross weight ratio of any intercontinental strategic system, giving it a relatively



Vanguard II Satellite and Instrumentation

Vanguard II weather reconnaissance satellite (AW Feb. 23, p. 31) is assembled (left) at Astro-Instrumentation Branch, U. S. Army Signal Research and Development Laboratory. Avionic instrumentation is stacked in decks in cylinder before being assembled in satellite.

low cost for the amount of destructive power delivered.

• **Such a missile** could penetrate at supersonic speeds for extreme ranges at low levels, if desired, and, since it would be aerodynamically controlled, it could change direction and dogleg. By using monitored inertial guidance techniques during all portions of a mission, excellent weapon delivery accuracies are possible.

Col. Armstrong has identified it in congressional testimony as an unmanned vehicle which would not have severe shielding problems. He also described it as having unlimited range but qualified his statement by adding: "When I say unlimited range, obviously I am not talking about it going on forever or anything of the kind . . . only that it is relatively weight insensitive. So this means that quite considerable payloads can be carried."

Dr. Merkle described the contamination problem as being so small that the missile could be well dispersed, by transporting it around the country on a truck trailer, and launched from almost any open space. Large boosters would be used to take the missile to the speed for ts nuclear ramjet to take over.

Guidance for the vehicle could be provided by any of several known systems. Col. Armstrong has mentioned, among others, a combination of inertial and map-matching systems that would provide considerably more accuracy in the intercontinental delivery of weapons than is possible with ballistic missiles.

One obvious benefit of the nuclear ramjet's ability to travel great distances at low altitude would be a low-level flight over an entire continent. Such a flight would make ground-based detection systems practically useless unless the missile passed almost directly overhead. Only airborne detection systems at great height would be truly effective against such an attack.

A possible configuration for this nuclear ramjet missile was outlined to Congress by Dr. Merkle. The reactor and necessary guidance and auxiliary equipment would be integrated into the ramjet to such an extent that the missile could be called a flying powerplant Dr. Merkle said:

"It is a very rugged machine. It is not flimsy at all. It is a kind of flying crowbar. . . . The reactor portion is . . . back here in the tail. Forward of the reactor is some coolant to keep the structure cool at this very high Mach number. Forward of that is the bomb compartment. Forward of that is the guidance equipment and the like. The structure—that is the entire airframe—can be built using existing technology. No new research is required there."

Such a missile probably would cruise somewhere between Mach 2 and 4 depending on altitude. Aerodynamic investigations conducted by the former National Advisory Committee for Aeronautics and other laboratories indicate that it is possible at these speeds to get acceptable lift-drag ratios using a wingless conical shape resembling a simple circular ramjet engine. Above Mach 5, the lift-drag ratios of such vehicles are approximately equal to those of the best winged configurations.

At any rate, lift-drag ratios would not be as critical for a vehicle with virtually unlimited range as they are for chemical fueled vehicles. Therefore, it is probable that the nuclear ramjet missile would not be complicated by using wings and dealing with the attendant cooling problems at high speed.

The atomic reactor required for such a missile varies considerably from the one required by the nuclear rocket which is having its feasibility proven by Project Rover at AEC's Los Alamos Laboratory. The rocket reactor must operate at considerably higher temperatures than the ramjet reactor, but it does not have to function for as long a time.

The rocket reactor must exist in a reducing atmosphere, while the ramjet travels in the atmosphere, and its reactor must withstand oxidation. Congressional testimony concerning the materials needed for this reactor indicate that, while much improvement can be expected in the future, materials exist now that have the proper oxidation resistance, strength and fatigue properties under the temperature and radiation levels that would exist in a supersonic nuclear ramjet. It also has been indicated that a useful ramjet reactor will be much smaller than that required for a nuclear rocket which could lift 10,000 lb. or more into orbit.

The reactor for the ramjet would resemble the one required for a direct cycle nuclear turbojet in many respects such as length of operating time desired, type of oxidizing environment that it would exist in and type of control response required. A primary difference between the two reactors is that the one for the direct cycle nuclear turbojet would have a shaft running through its center to connect the turbine and the compressor.

Control response required by the ramjet reactor would be exact, but it is be-

FLIGHT CONTROLS

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Flight Controls offers one of the most challenging areas of work at Lockheed's Missiles and Space Division.

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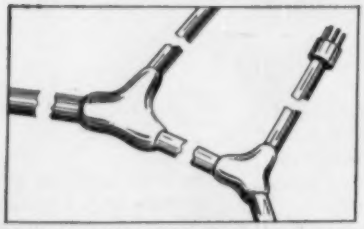
CABLE *and* **WIRE LEADS**

by HOWARD E. PENDERGAST
Technical Director, Rex Corporation

Engineering reliability into cable assemblies



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Constant Review

Washington—Project Pluto has been under review by some form of committee or evaluation board during most of its three-year existence, according to Air Force Col. Jack L. Armstrong, deputy chief of the Aircraft Reactors Branch of the Atomic Energy Commission's Division of Reactor Development.

Col. Armstrong believes that project review by outside experts is basically a sound policy and could be termed as essential, but he also feels that the present methods fall short in these areas:

- **Project review should be annual or semi-annual to keep from using too much of the time of project personnel for briefings and presentations to the reviewing group.**
- **Reviewing committees should include experts in every phase of the activity or development that they are reviewing. This is rarely ever done, he says ,and each committee tends to concentrate on the particular phase that they know best. Their advice and actions frequently conflict with those of other committees which had to deal primarily with another segment of the total problem.**
- **Committee members are usually on several reviewing bodies at one time besides holding down one or more permanent positions. This does not provide them with adequate time to review any one project.**
- **Reviewing committees should have authority to give advice only rather than to arbitrarily change the program of any project.**
- **Reports by reviewing committees should be shown to the project which was reviewed before they are released. This would allow correction of any misunderstanding of fact by the reviewing committee before the issuance of the report.**

lieved by Project Pluto personnel to be within the state of the art. Since the air passing through the ramjet functions as a coolant for the reactor as well as the medium for producing thrust, the reactor must adjust its power level quickly as the vehicle changes altitude, and the density of the coolant gas changes. A controllable inlet and nozzle on the ramjet would greatly reduce the power change requirement placed on the reactor.

The present reactor development effort in Project Pluto is directed in three principal directions—materials, nuclear physics and mechanical engineering. Materials improvement is described by Dr. Merkle as being the most important.

A test area at Jackass Flats, AEC's Nevada Test Site, has been set aside for Project Pluto. This has been designated "401 area," and it is close proximity to the "400 area" assigned Project Rover. The test facilities for Pluto have not yet reached the advanced stage of construction of those in the Rover area.

While the Pluto installations will serve roughly the same purpose as those for Project Rover, it was decided that money could be saved in the long run if the facilities were kept separate.

The Pluto installation differs in layout somewhat from the Rover area which was shown in the Feb. 16 issue of AVIATION WEEK (p. 49). A materials test installation is located about two miles from the control building; a disassembly building is about two miles from the materials test facility and connected with it by a railroad line. After a test, remotely controlled locomotive will move the test specimens and reactor along the track to the disassembly building where an inspection of the radioactive equipment will be performed remotely from behind heavy shielding.

A hot critical assembly building is located adjacent to the control building. Nuclear physics experiments will take place there, primarily to determine if the criticality of a pile changes at elevated temperatures. At present, most knowledge of criticality has been gained at room temperatures or slightly above. To get the information needed for the nuclear ramjet, an oven and blower system are being built in the hot critical assembly building so that hot air can be blown over pile.

Measurements taken during these tests will show if there is a reactor control reversal at high temperatures. While such a control reversal is not expected, no information is available now to show exactly what to expect.

This is similar to the situation existing in the flight testing of a number of aircraft in the past when they experienced unexpected control reversals at various speeds and attitudes. It is possible that at certain temperatures the reactor control rods should be pulled out rather than pushed in to reduce power.

This experimental pile in the criticality experiments does not become radioactive so that they can be performed close to the control building.

While construction in the Project Pluto "401 area" is not as advanced as that in the nuclear rocket area, the project itself is considered to be in a more advanced state, and most project officials believe that a workable nuclear ramjet will precede the nuclear rocket.

Missile Prepackaging May Soften Navy Resistance to Liquid Fuel

By Russell Hawkes

Pasadena, Calif.—Prepackaged, storable tanks of liquid rocket propellants and a throttle-controlled rocket with thrust precisely variable from zero to maximum have been developed by Naval Ordnance Test Station, China Lake, Calif.

These developments may soften Navy resistance to liquid propellants in military missiles. NOTS scientists are convinced they can be incorporated in weapon system development relatively soon.

The combination of storable liquid propellants and complete command control of thrust offers important advantages. Storables offer the same quick readiness as solids. Specific impulse and mass ratio, which determine performance, can be similar to those of rockets using familiar non-storable liquid propellant combinations.

Navy will not identify the storable combinations it has used successfully, but the ones which NOTS experts call their "workhorse" propellants are hypergolic, have been stored in aluminum containers for five years without deterioration of tanks and dropped 40 ft. onto steel decks without serious damage. Navy claims factory-filled missile tanks of the workhorse propellants are highly resistant to thermal shock and gunfire.

Hazard Factor

The storables are toxic and highly corrosive to living tissue but NOTS studies indicate that these hazards are more easily controlled than expected. Navy scientists say the proper criterion of storability is the boiling temperature of the propellant rather than corrosivity or the effect upon human beings for it determines internal pressures upon the tank. Also, if boiling point is exceeded it may affect the properties of the propellant and its behavior during operation of the rocket. Corrosion is considered an easier problem because there is always some tank material to be found which is compatible with the propellant. Cryogenic (liquefied gas) oxidants are obviously eliminated by the high boiling point requirement.

Storable propellant tanks must be designed to withstand heavy handling but if propellant is pump-fed to the combustion chamber, unpressurized tanks can have aluminum walls as light as 0.1 in. thick.

NOTS throttle-controlled rocket requires hypergolic fuels which may include ozones and fluorine combinations as oxidants. There have been other variable thrust rocket engines and some are in use in manned aircraft but the degree of thrust regulation is tightly limited because changing the propellant flow rate varies the pressure drop across the injector face.

Some level of injector efficiency is necessary to the operation of the thrust chamber and since injector efficiency may vary sharply with the pressure drop, it is obvious that complete command control of thrust cannot be had merely by varying propellant flow rate. Solution of this problem is the key to the NOTS development. NOTS scientists refuse to answer questions about it but it is apparent that injector geometry must be varied to keep pressure drop within an acceptable range throughout the complete range of propellant flow rates.

Development of the thrust control system was a low cost NOTS program which lasted 30 days and aside from the time spent in conceiving the idea required a little over four man-hours of labor. Heart of the hydraulically powered system is a truck brake master cylinder bought retail at an auto supply house. Something very similar to the experimental system could be delivered for about $50.

Command-controlled thrust makes it possible for a missile or space ship to achieve a very precise burnout velocity without difficult preprograming of thrust termination for it makes small corrections possible at end of burning.

Entry to a moon orbit requires that a burnout velocity of about 39,000 fps. be reached with a tolerance of about 4 fps. Command-controlled corrections would obviously improve the probability of a successful trip and would simplify guidance equipment producing an improvement in reliability.

In a military missile the combination of command control and storable liquid propellants can result in quicker readiness and in missiles with longer range or greater payload for the same external dimensions.

Navy Plans Development Program For Polaris High-Yield Warhead

Washington—Navy programs for development of a guided-missile warhead for the Polaris fleet ballistic missile with more than twice the present yield and lightweight nuclear warheads that could be fired from guns or dropped from helicopters in anti-submarine warfare were outlined by Adm. Arleigh Burke, Chief of Naval Operations, to the Senate Foreign Relations Disarmament Subcommittee.

Adm. Burke cautioned the subcommittee that an international ban on nuclear weapon testing would mean a freeze on these projects and prevent their ultimate development.

Greater Yield, Less Weight

"There are great prospects of increasing the yield and decreasing the size of weapons," Adm. Burke told the subcommittee. "In Polaris we have a satisfactory warhead, but if the tests were to continue, we could probably get a warhead weighing the same amount which will have two or three times the present yield.

"Also, we would like to go into real small weapons—depth charges that could be fired from a gun, for example. Some day we will be able to achieve that if testing continues."

Although improvement continues in missile propulsion and guidance, Adm. Burke said that this progress will not compensate for a stand-still in warhead development. The Navy, he said, is "on the tack now of making a significant improvement in the specific impulse of solid propellants, and we expect to have ballistic missiles which will use all inertial guidance."

Polaris Progress

Adm. Burke's report on Polaris missile project was optimistic:

- **The first missile,** he said "is scheduled to be in full operation in the fall of 1960." Although the programed build-up of three (Polaris submarines) a year is conservative, and the Navy would like to have it accelerated, he noted: "Each of these subs carries quite a few weapons, and it does not take very many of those weapons to wipe out a considerable area, and each one of these subs will handle quite a few areas."
- **He estimated that the Soviet Union** has conducted "considerable research" on ballistic missiles for submarines "based upon their land research data on ballistic missiles." Russia "could" have ballistic missile submarines now, Adm. Burke said, "but I do not think they have very many."
- **Polaris "in the next year or** so can be put on surface ships," he said. As with submarines, Adm. Burke pointed out, the great advantage is that the enemy would not know which ships have bal-

listic missiles and which have not.

In addition to blocking development of small warheads for anti-submarine warfare, Adm. Burke said that a ban on nuclear tests also would prevent the Navy from developing urgently needed data on lethal areas of atomic impact at sea. He explained:

"We still need to know the range at which a significant jolt would be received. . . . We know the lethal range of an atomic weapon pretty well at various depths from our underwater tests. . . . But we do not have enough data on how far our own ships should be away from the explosion in order not to get operational damage." Rough data indicates range from explosion should be 2,000-3,000 yd., he said.

A nuclear grenade device which could be fired from guns for anti-submarine warfare, Adm. Burke said, "would be a lot cheaper and easier" than the rocket launched depth charge which Navy now has in the design stage. "What we are trying to do is develop a way to use our present gun platforms and fire control equipment without putting more expensive equipment in the ships," he commented.

Offshore Civil Aircraft Corridor Opened by Pacific Missile Range

Pt. Mugu, Calif.—Pacific Missile Range headquarters here has opened a corridor in its reserved airspace offshore for part-time use of transpacific civil air traffic.

At Pacific Missile Range suggestion, Federal Aviation Agency has given the corridor a dual designation as a control area (C-1176) and a warning area (W-537). The range will try to build its firing schedules around known airline schedules and transpacific flights will be cleared through corridor between firings.

The area would be under the jurisdiction of the Los Angeles Air Route Traffic Control Center which would designate it a Warning Area at Pacific Missile Range request.

The idea of dual designated airspace is not new but this is the first time it has been applied. Military and airline men believe its wider use would do much to straighten out the present tortuous air route structure. The Pacific Missile Range dual designated area became effective Jan. 1.

Former Policy

For some time Pt. Mugu has been granting direct transit clearance to commercial carriers on request and denying clearance only when there was potential conflict with missile operations or when a clear flight path could not be guaranteed. This has been continued and to date over 95% of all transit requests have been granted.

An elaborate surveillance radar network is an essential part of planned Pacific Missile Range instrumentation. The range, Air Defense Command and Federal Aviation Agency are working out ways to fit this network into the national Air Route Traffic Control system and make nearby ARTC facilities available for special Pacific Missile Range missions. The range's equipment is being sited with this end in mind and all surveillance data will be made available to Air Defense Command, Los Angeles ARTCC and anyone else who has a legitimate need for it.

Data relay systems being installed are designed so that other potential users will have access to the information as soon as correct receivers and display units are installed. Pacific Missile Range has tried to make the system compatible with those planned by FAA and Air Defense Command.

Navy missile-carrying fighters out of planned Naval Air Station, Lemoore, Calif., will carry out firing practice in Pacific Missile Range. To get these aircraft through the Monterey-Point Sur area and within the boundaries of the range's precision control network, range controllers will have to rely on surveillance data from FAA facilities to be installed at Paso Robles and Monterey. Federal Aviation Agency and its predecessor, Airways Modernization Board, have studied PMR-ARTCC coordination plans and the use of dual designated airspace with an eye to using the same methods elsewhere in the country.

A problem as yet unsolved by the range is the passage of unannounced civilian light aircraft through the range's restricted areas. At NMC Pt. Mugu an average of three lightplanes a week pass through the traffic pattern which includes high performance jets and drones without warning. So far NOTAMs (notice to airman), letters to airport managers and every other formal and informal communication have failed to improve the situation. Adm. Jack Monroe, Pacific Missile Range commander, concedes the importance of the coast route to private pilots and is offering NMC control facilities to overflying aircraft, has gerrymandered NMC restricted area (R-100) to fit prominent landmarks and has placed a 3,000 ft. ceiling over military aircraft in the area.

NASA Contracts

Washington—Following is a contract-by-contract breakdown of National Aeronautics and Space Administration research and development contracts of over $50,000 let from the organization of NASA on Oct. 1, 1958, through Jan. 31, 1959. First dollar figure given represents 1959 obligations, the second figure represents the total estimated dollar value of the contract, which in some cases will extend over several years.

NASA Headquarters

California Institute of Technology, Jet Propulsion Laboratory; program, aircraft, missile and spacecraft research support of JPL plant and conduct of research; contract number, HS-41; $8,160,000; $8,160,000.

Yale University; program; aircraft, missile and spacecraft research, research contracts for molecular study; NASW-21; $110,000; $110,000.

Office of Naval Research, Naval Research Laboratory; program: scientific investigations in space, sounding rockets and partial support of Space Sciences Division; HS-47; $1,900,000; $1,900,000.

Air Research and Development Command, USAF, Ballistic Missile Division; program; scientific investigations in space on earth satellites, including Thor-Able boosters; H-6; $7,120,000; $7,120,000.

Army Ordnance Missile Command; program: scientific investigation in space on earth satellites and Juno II boosters; HS-21; $8,540,000; $8,540,000.

U. S. Department of Commerce, National Bureau of Standards, program: scientific investigation in space, earth satellites and computing services (60%); HS-37; $80,000; $80,000.

Alton Engineering Co. program: scientific investigation in space on earth satellites and alterations to buildings 5-7 at Bellview Annex, NASW-20; $130,000; $130,000.

Office of Naval Research, Naval Research Laboratory; program: scientific investigation in space, earth satellites and partial support of Space Sciences Division; HS-47; $2 million; $2 million.

U. S. Department of Commerce, National Bureau of Standards; program: scientific investigation in space, earth satellites and research on rubidium frequency standards; HS-48; $270,000; $270,000.

Iowa State University; program: scientific investigation in space, earth satellites, reduction analysis; NASW-17; $10,000; $19,320.

Army Ordnance Missile Command; program: scientific investigation in space, earth satellites, lunar probe projects; HS-1; $2,110,000; $2,600,000.

Air Research and Development Command, Ballistic Missile Division; program: scientific investigation in space; lunar probe projects; HS-2; $2 million, $2 million.

Office of Naval Research, Naval Ordnance Test Station, China Lake, Calif.; program: scientific investigation in space; lunar probe projects; HS-3; $200,000; $200,000.

U. S. Department of Commerce, National Bureau of Standards; program: scientific investigation in space; computing services; HS-37; $40,000; $40,000.

Air Research and Development Command, Ballistic Missile Division; program: scientific investigation in space; deep space probes, space probes; HS-5; $8,990,000; $8,990,000.

Army Ballistic Missile Agency; program: scientific investigation in space; deep space probes, deep-space study; HS-20; $340,000; $340,000.

California Institute of Technology, Jet Propulsion Laboratory; program: scientific investigation in space; deep space probes, deep-space study; HS-20; $1,300,000; $1,300,000.

U. S. Department of Commerce, National

(Continued on p. 53)

WHAT DOES IT TAKE TO BUILD MISSILE SYSTEMS?

IT TAKES all of the dynamic resources, technology and skilled man power of the entire defense complex—the best of the military, government and industry.

The staggering sum of $3.3 billion was spent on missiles alone in 1958 and this level will continue, probably increase in the future.

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Honeywell Growth—Honeywell has a history of growth. In the past ten years sales have increased from $57.6 million in 1948 to $328 million in 1958. Employment has increased from 8600 to 32,000 in the same period while net earnings have increased from $5.9 million to $22.6 million.

Strength from Profits—A vital factor in Honeywell's growth has been its consistently profitable operations coupled with conservative financial policies. This has enabled the company to plow back earnings ($66 million in the past ten years); readily obtain adequate financing.

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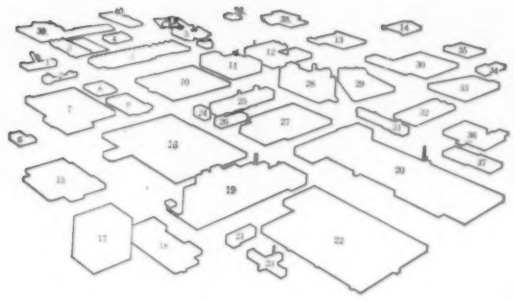
HONEYWELL FACILITIES. The 38 plants combined in the illustration at right show Honeywell's manufacturing, engineering and research facilities brought together in one community. Not shown are the company's warehouses, smaller manufacturing plants, and 166 sales and service offices throughout the world.

BUILD MISSILE SYSTEMS?

HONEYWELL MANUFACTURING AND RESEARCH FACILITIES IN THE UNITED STATES, CANADA AND OVERSEAS



1. Amsterdam, The Netherlands, Honeywell N. V. · Temperature Controls.
2. Frankfort, Germany, Honeywell G.m.b.H. · Valves.
3. Newhouse, Scotland, Honeywell-Brown Limited · Industrial instruments, MICRO SWITCH switches and control devices.
4. Amiens, France, Honeywell S.A.R.L. Temperature controls.
5. Tokyo, Japan, Yamatake-Honeywell Keiki Company Ltd. · Industrial instruments, MICRO SWITCH switches, commercial controls.
6. Seattle, Development Laboratory Underwater ordnance equipment.
7. Los Angeles, Gardena Plant Gas appliance controls.
8. Los Angeles, Aero West Development Center · Missile systems and components.
9. Los Angeles, Duarte Plant Missile systems and components.
10. Chicago, Morton Grove Plant Temperature controls.
11. Freeport, Illinois, Plant 2 MICRO SWITCH precision and mercury switches.
12. Freeport, Illinois, Plant 1 MICRO SWITCH precision and mercury switches.
13. Denver, Heiland Division Recording oscillographs and photographic equipment.
14. Minneapolis, Wold Chamberlain Field · Flight test and hangar facilities.
15. Minneapolis, Brede Plant Missile systems and components.
16. Minneapolis, Golden Valley Plant Plastic moldings and Minneapolis warehouse facilities.
17. Minneapolis Downtown Plant Temperature controls.
18. Minneapolis, Ramsey Plant Custom control panels.
19. Minneapolis, Main Plant Administrative offices, temperature controls, transistors.
20. Minneapolis, Stinson and Ridgway Plants · Aeronautical and missile systems and components.
21. Minneapolis, Nicollet Building Temperature controls sales school and transistor design.
22. Minneapolis, Hopkins Plant Missile systems and components.
23. Minneapolis, Honeywell Research Center · Corporate basic research.
24. Philadelphia, Industrial Education Center · Industrial controls sales school.
25. Philadelphia, Olney Plant Industrial instruments, controls.
26. Philadelphia, Rubicon Building Industrial instruments, controls.
27. Philadelphia, Fort Washington Plant · Industrial control valves.
28. Philadelphia, Luzerne Plant Industrial instruments, controls.
29. Philadelphia, Main Plant Industrial instruments, controls.
30. Toronto, Ontario, Honeywell Controls Limited · Complete line of Honeywell products in Canada.
31. Wabash, Indiana, Main Plant Temperature controls.
32. Wabash, Indiana, Bond Street Plant · Electronic air cleaners.
33. Boston, Brighton Plant Aeronautical and missile systems and components.
34. Boston, Charles River Plant · Aeronautical, missile systems, components.
35. Boston, DATAmatic Corporation Electronic data-processing equipment.
36. St. Petersburg, Florida, Aeronautical Inertial Center Aeronautical and missile systems and components.
37. Beltsville, Maryland, Davies Laboratories · High-speed data-recording systems.
38. Manchester, New Hampshire, Marion electrical instruments.
39. Pottstown, Pa., Missile ground support equipment.
40. Fall River, Mass. Industrial instruments, controls.

WHAT DOES IT TAKE TO

It Takes Organization

HEADED by a Group Vice President, the Military Products Group combines the experience and facilities of four of the company's divisions grouped to serve the military market with more effectiveness. These divisions are represented to the military by a single integrated sales force. The group is able at any time to draw on the Corporate Research Center and on other Honeywell divisions.

Integrated Divisions—The four major divisions incorporated into the Honeywell Military Products Group produce in excess of $100,000,000, or 30% of the Company sales. Their typical areas of activity are:

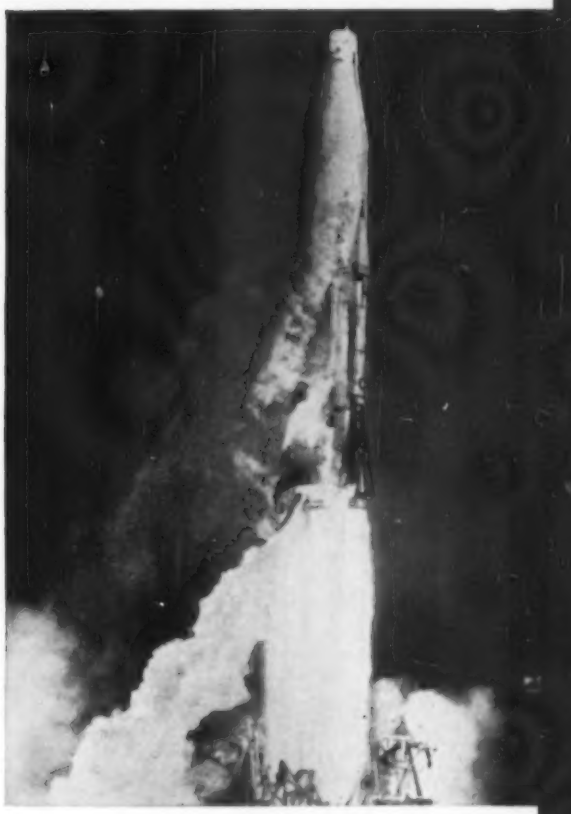
AERONAUTICAL DIVISION—located in Minneapolis, Minnesota; Los Angeles, California; St. Petersburg, Florida.

Missile systems and components including inertial guidance systems, missile stabilization systems and components, advanced flight control systems and ground support equipment, bombing systems, electronic fuel measurement systems, engine control and instrumentation systems, precision gyros and other components.

BOSTON DIVISION—located in Boston, Massachusetts.

Missile systems and components including gyros, accelerometers, synchros, proximity switches, servos, de-

BUILD MISSILE SYSTEMS?



modulators, instrumentation and telemetering equipment, amplifiers and other equipment for precision measurement and control.

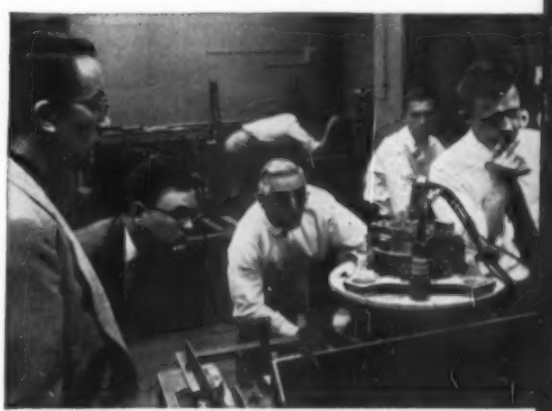
MISSILE EQUIPMENT DIVISION—located in Pottstown, Pennsylvania.

Ground support equipment for high pressure gas systems, cryogenic systems, programming equipment and simulators for functional checking of ground support systems.

ORDNANCE DIVISION—located in Minneapolis, Minnesota; Los Angeles, California and Seattle, Washington.

Missile systems and components including fuzes, safety and arming mechanisms, munitions, warheads, underwater ordnance and sonar systems, ground support equipment, fire control systems, infrared systems, communications equipment, and cryptographic equipment.

Capability in Depth—Today, Honeywell's Military Products Group includes a combined force in excess of 9,000 people—over 1,000 of whom are graduate engineers. Its engineering and production areas exceed one million square feet, with 15 factories and facilities in seven cities. The combined experience and resources represented in this group make it one of the largest sources in the country for research, engineering and production capabilities for precision military electronics.



WHAT DOES IT TAKE TO

It Takes Experience

A DEPTH of experience along broad lines is available from the Military Products Group which presently has complete weapons system responsibility for several missile projects—two of which are an antisubmarine missile and an air-to-surface missile—with extensive experience in all phases of the programs, from research and development to final user tests.

Missile and Space Systems—With a notable background in missile and space systems management, as well as in system and component design, development and production, and testing, Honeywell has the capabilities, experience, personnel and facilities necessary for work with all phases of prime missile and space systems.

ANTISUBMARINE. The Ordnance Division has been under contract to the Navy's Bureau of Ordnance for the ASROC missile program since early in 1956. As a prime contractor, Honeywell Ordnance has been responsible for systems management, coordination and direction of all phases of the project including the missile, fire control, launcher, warhead, test, checkout, and training equipment. A special engineering branch at Los Angeles, California, was established to promote liaison between Honeywell and the Naval Ordnance Test Station which has technical supervision of the project.

AIR-TO-GROUND MISSILE SYSTEM. The Aeronautical Division entered into contract with the Air Force Armament Center in 1956 to develop, test, and produce initial quantities of a classified missile system, a program that points out the Military Products Group's ability to function as a corporate team. As prime contractor, Honeywell Aero has systems management responsibility in this program, which includes all phases of the weapon development including launch means, storage and preflight checkout equipment, airframe design and guidance system. The atomic warhead adaption kit is being handled by the Ordnance Division; the propulsion system is sub-contracted.

SPACE FLIGHT CONTROL AND GUIDANCE. Honeywell is a member of the Martin team for developing the Air Force's boost-glide aircraft called Dyna-Soar, and is conducting preliminary development analysis of certain classified control aspects for Dyna-Soar's pilot controlled space flights. Honeywell is also working directly with the National Aeronautics and Space Administration on the stabilization control of space vehicles. In this same field Honeywell is responsible for the stabilization control of McDonnell Aircraft's "Project Mercury" program.

SPACE ENVIRONMENT. Honeywell is currently working on a space capsule and its environment control systems. Drawing on the corporation's unmatched experience as the world's leading producer of environmental controls and systems, Honeywell engineers are developing a control system to maintain a livable environment for a man in a capsule in space. This work involves

BUILD MISSILE SYSTEMS?

design of the complete system for cabin control and the modification and integration of components into a reliable, accurate system.

Missile Sub-Systems and Components—Honeywell's Military Products Group has been active in the design, development, production and testing of various sub-systems and components for a wide range of missiles which includes: Falcon, Little John, Sergeant, Thor, LaCrosse, Honest John, Corporal, Redstone, and Sidewinder, plus Atlas, Titan and Polaris, still under development.

Fields in which the Group has distinguished itself are—Inertial Guidance Systems and components, including the gyro reference systems for Titan and Vanguard—Advanced Flight Control Systems, where we are the largest manufacturer—Instruments, including fuel measurement systems for all of America's jet transports—Fuzing and Arming Systems for many of our operational missiles—Warhead systems for such missiles as Honest John and Little John—and others: Safety and Position Guarantee Systems—Test and Checkout equipment—Thermal Batteries and Power Supplies—Trainable Launchers—Ground Handling Equipment—Ground Support Equipment—Atomic Warhead Adaption Kits—Airframes—Telemetry—Transistors—Infrared Systems—Instrumentation—Computors—Sonar.

Much of the work in these fields has been directed toward research and development of better equipment to meet ever-changing missile parameters. The attitude of restlessness in research that grew with the Honeywell corporation is thoroughly instilled in the divisions of the Military Products Group, and this is one of the reasons why Honeywell has so rapidly forged to the front in space and guided missile work.

Specialized Techniques—In the extensive work done by the Military Products Group in all phases of missiles, special techniques had to be developed for nearly every segment of the various programs. In response to these special requirements, Honeywell engineers and technicians have mastered the necessary techniques to the point that now many of them are routine. A partial list follows.

RELIABILITY TECHNIQUES—In obtaining accurate reliability figures for components and systems, life tests, chain law of probability ratio and other test methods are used. Honeywell has complete environmental laboratories, capable of performing all standard military qualification tests, and has had extensive experience in supersonic sled testing.

PRODUCTION TECHNIQUES—Honeywell Research and Production personnel are constantly experimenting with new production methods and materials—coil windings using precious metal wire five times finer than a human hair, machining techniques guaranteeing accuracies of 25 millionths of an inch, exotic metals such as beryllium—and developing workable high-temperature compounds such as ceramics and cermets.

MINIATURIZATION, TRANSISTORIZATION, PRINTED CIRCUITRY—For years the divisions of the Military Products Group have produced practical designs in these important areas, and many proven components now produced for missiles incorporate Honeywell miniaturization, printed circuitry and transistor techniques. These are immeasurably aided by Honeywell's own producing Transistor Division, which enables the Honeywell designer to maintain quality control in the use of these solid-state electronic devices.

SPACE-FLIGHT REQUIREMENTS—In addition to advanced work in the more glamorous aspects of space flight, such as guidance and flight control, Honeywell is deeply involved in the more prosaic but equally important field of Human Factors—cockpit layout, environmental controls, food preservation and growth, high temperatures, acceleration and other factors—without which manned space flight, as presently envisioned, will be impossible.

PROVEN past performance backs up Honeywell's progress in the new fields of missiles and space. The Aero Division has produced 45,000 autopilots, 128,000 engine turbo-regulator controls and 293,000 gyros. Honeywell designed and manufactured the first practical electronic fuel measurement system and is now the major supplier. In addition, the company produced the first flight control system designed for supersonic aircraft, and years ago mastered techniques necessary for mass-producing a complete line of hermetic integrating gyroscopes which are the most accurate in the world. Honeywell not only makes the smallest floated gyro, but also the smallest conventional gyro, the Golden Gnat, which weighs only three ounces.

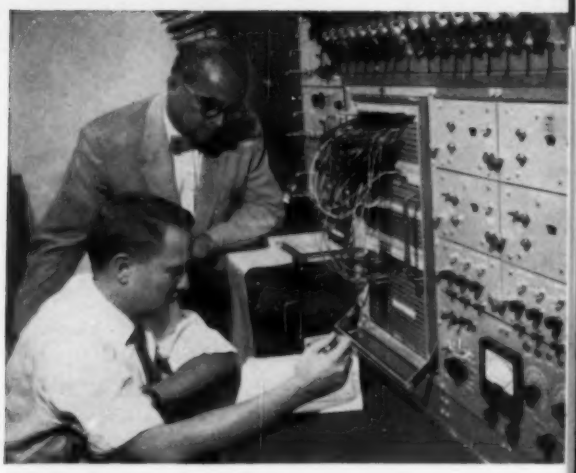
It Takes People

Honeywell has a vast store of engineering "know-how" among its more than 31,000 employees. One out of every ten employees is actively engaged in either research or engineering work. The list of specialties is impressive, covering almost every field of Technology and Science.

In organizing a research, development and production program for a missile system, a Military Products Group task force is formed with direct line responsibility for completion of the particular project. This force is formed of key technical and administrative personnel drawn from all four divisions. Yet it is significant that the personnel and resources of any one division comprises only a part of the pool of experienced manpower that makes up the whole of Honeywell.

Honeywell, through its Military Products Group, has accepted a commitment to long-range service in the defense effort. In rendering this service, Honeywell is well prepared to call upon its resources in order to produce more effectively both for the military, and our growing commercial business.

Detailed information on any phase of the Military Products Group's activities can be obtained by writing: Military Products Group, Minneapolis-Honeywell Regulator Co., Minneapolis 8, Minn.



Honeywell

H HONEYWELL *Military Products Group*

(Continued from p. 44)

Bureau of Standards; program: scientific investigation in space, deep space probes, computing services; HS-37; $10,000; $10,000.

U. S. Army Corps of Engineers; program: scientific investigation in space; deep space probes, construction of addition to building No. 125 at JPL; HS-40; $150,000; $150,000.

Iowa State University, program: scientific investigation in space; deep space probes, space probe instrumentation; NASW-17; $40,000; $292,000.

Office of Naval Research, Naval Research Laboratory; program: scientific investigation in space; Vanguard Division, support of the Vanguard Division, Space Projects Center; HS-23; $23,500,000; $23,500,000.

Army Ordnance Missile Command; program: satellite applications investigations; communications, 100 ft. inflatable sphere; HS-4; $2,150,000; $2,150,000.

Air Research and Development Command, Wright Air Development Center; program: space propulsion technology; high-energy fuel rockets, "state-of-art" work on rocket engines; HS-13; $430,000; $430,000.

California Institute of Technology, Jet Propulsion Laboratory; program: space propulsion technology; high-energy fuel rockets, development of 6,000 lb. thrust storable propellant system; NASW-6; $2 million; $3,400,000.

North American Aviation Inc., Rocketdyne Division; program: space propulsion technology; one-million lb. thrust single chamber engine, one-million lb. thrust rocket engine; HS-10; $10 million; $102 million.

Atomic Energy Commission; program: space propulsion technology; nuclear rocket engines, Rover program; HS-15; $1,900,000; $1,900,000.

Republic of Peru; program: supporting activities; tracking and data acquisition, operation of earth satellite radio tracking and receiving stations for six months beginning 1/1/59; NASW-7 $75,000; $75,000.

University of Chile; program: supporting activities, tracking and data acquisition; operation of two earth satellite tracking and receiving stations beginning 1/1/59; NASW-19; $80,000; $80,000.

Bendix Radio Corp., program: supporting activities, tracking and data acquisition; operation of Minitrack stations in South America and Cuba for 18 months beginning 1/1/59; NASW-11; $600,000; total amount of contract still under negotiation.

Smithsonian Institution, Smithsonian Astrophysics Laboratory; program; supporting activities, tracking and data acquisition; photo reduction equipment; HS-22; $120,000; $120,000.

Smithsonian Institution; program: supporting activities, tracking and data acquisition; tracking and data reduction services; HS-32; $470,000; $470,000.

Langley, Va., Research Center

Endebrock-White Co.; program: aircraft, missile and spacecraft research; support of NASA plant, modification of the impact basin to provide working space for Space Projects Center personnel; NA1-3679; $60,000; $60,000.

Lewis Laboratory, (Cleveland)

Minneapolis-Honeywell Regulator Co., program: space operations technology; manned space flight, furnishing automatic flight control systems; NAS3-305; $140,000; $140,000.

Douglas Aircraft Co.; program: space operations technology, high-energy fuel rockets; propellant tank assemblies; NAS3-262; $110,000; $110,000.

Solar Aircraft Co.; program: space operations technology, high-energy fuel rockets; furnishing rocket thrust chambers and necessary tooling; NAS3-234; $180,000; $180,000.

Space Projects Center (Langley)

Department of the Navy, Bureau of Ordnance; program: scientific investigation in space, earth satellites, X-248 rockets; S-1000 (G); $100,000; $100,000.

Department of the Navy, Bureau of Ordnance; program: scientific investigation in space, earth satellites, X-254 rockets; S-1010 (G); $1,120,000; $1,120,000.

Department of the Navy, Bureau of Aeronautics; program: scientific investigation in space; earth satellites, Jupiter seniors; NAS-5-53; $1,020,000; $1,020,000.

Department of the Army, Chief of Ordnance, Army Ballistic Missile Agency; program: scientific investigation in space; earth satellites; XM-45 rockets; S-1013 (G); $90,000; $90,000.

Department of the Army, Chief of Ordnance, Army Ballistic Missile Agency; program: scientific investigation in space, earth satellites; TX-33-20 rockets; L-55-931 (G); $620,000; $620,000.

U. S. Air Force, ARDC Ballistic Missile Division, program: space operations technology; manned space flight, Atlas-D boosters; HS-24; $1,400,000; total amount of contract still under negotiation.

U. S. Air Force, ARDC Ballistic Missile Division; program: space operations technology; manned space flight, Atlas-D boosters; HS-36; $5,600,000; total amount of contract still under negotiation.

Department of the Army, Chief of Ordnance, Army Ballistic Missile Agency; program: space operations technology; manned space flight, XM-45 rockets; S-1013 (G); $120,000, $120,000.

Aerojnb Development Co., program: space operations technology; manned space flight, booster hardware, sets for TX-33; NAS5-51; $70,000; $70,000.

Thiokol Chemical Corp.; program: space operations technology; manned space flight; XM-19E1 rockets; NAS5-55; $110,000; $110,000.

Department of the Army, Chief of Ordnance, Army Ballistic Missile Agency; program: space operations technology; manned space flight, TX-33-20 and TX-33-22 rockets; L-55-931 (G); $2,200,000; $2,200,000.

Department of the Army, Army Ordnance Missile Command; program: space operations technology, manned space flight, part of Redstone boosters; HS-44; $4,590,000; $15,500,000.

North American Aviation Inc., Missile Division; program: space operations technology; manned space flight, transport vehicles and launcher (S-91-4); NAS5-57; $400,000; $400,000.

Department of the Army, Army Ordnance Missile Command; program: space operations technology; manned space flight, Jupiter boosters; HS-54; $2,740,000; $4,450,000.

AMC Contracts

Wright-Patterson AFB—Ohio: Following is a list of unclassified contracts for $25,000 and over as released by the Air Materiel Command.

AMC AERONAUTICAL SYSTEM CENTER, Wright-Patterson AFB, Ohio.

Kittell-Lacy, Inc., El Monte, Calif., construction and calibration of sound suppression structure for Air Force field test stand, (PR 16583), $46,978.

David Clark Co., Worcester, Mass., 20 full-pressure altitude suit assemblies and various suit assembly components to be used to accomplish the required testing and integration into the X-15 research vehicle project, and also to accomplish testing which will enable the performance characteristics of the items obtained, (PR EM-9-RD-6155), $238,625.

Convair Division, General Dynamics Corp., San Diego, Calif., development and evaluation of sub-zero machining methods, (PR PB-8-MMP-6173 and amendment no. 1), $132,028.

The Goodyear Tire & Rubber Co., Akron, Ohio, wheels, brakes, spare parts and data for B-57, B-57D, C-130B and F-105B aircraft, (PRs 00-8-03B-1815, PE-9-03B-4093, 4202 and 4137), $597,735.

J. A. Maurer, Inc., Long Island City, N. Y., 40 pair nuclear flash eye protectors, (PR 09735), $29,367.

Jack & Heintz, Inc., Cleveland, Ohio, starter, electric, direct cranking in a/w AN 4116R5B, AN 4116R6B for C-97, C-118 and C-124 aircraft, (PR SA-9-03C-8217, MIPR-R59-4054-TCSMC-E), $290,930.

Red Bank Division, Bendix Aviation Corp., Eatontown, N. J., research and development of two types of external anode triodes, (PR PB-8-MMP-6259), $65,482.

Sperry Gyroscope Co. Division, Sperry Rand Corp., Great Neck, N. Y., radar set, AN/APN-59, spare parts, ground support equipment and data for C-130B C-133B and KC-135A aircraft, (PR's PE-9-16K1-4193 and amendment no. 1, MD-9-16K1-55053, MD-9-16K1-55128, WR-9-Maint-83 and amendment no. 1, EC-9-16K1-4376), $2,892,534.

Permanent Filter Corp., Los Angeles, hydrant fueling system servicing vehicles, test, reports, engineering data, handbook, special test equipment and elements for filter separators, (PR EM-9-S-6248), $88,000.

Bowser, Inc., Fort Wayne, Ind., hydrant fueling system servicing vehicles, test, reports, engineering data, handbooks, special test equipment and elements for filter separators, (PR E-9-S-6248), $72,000.

Red Bank Division, Bendix Aviation Corp., Eatontown, N. J., generators, 30 volt, 400 amp., d.c., P/N30B26-1-A; panels, protection, d.c., type MD-1, P/N 34B15-1-A, spare parts, maintenance tools and test equipment and data for F-105 aircraft, (PR PE-9-03C-4245), $215,792.

United States Gauge Division, American Machine & Metals, Inc., Sellersville, Pa., type MS 28046-W1 airspeed indicators (replenishment spares), (PR MA-9-05C-212 (complete), $83,888.

Hughes Aircraft Co., Culver City, Calif., 112 MA-1 aircraft weapon control systems to be utilized in F-106 aircraft, (PR PE-9-11B-4056), $18,874,800.

Lear, Inc., Grand Rapids, Mich., indicator, attitude, settable pitch in a/w exhibit WCLCI-1-70A, for service test on X-15 aircraft, (PR PE-8-05C-3765), $95,930.

The Scranton Corp., Chicago, Ill., altenator assembly engine-driven 8 kva. 115v, single phase variable frequency type B1 USAF specification MIL-A-26283, dated January 27, 1958, and data for use on C-97, C-124, T-29, KC-97, RB-50, TB-50, WB-50, YC-97 and KB-50 aircraft, (PR SA-8-03C1-6662), $429,070.

The General Tire & Rubber Co., Akron Ohio, wheels, brakes, spare parts and data, spares for F-100D and F and T-37A aircraft, (PR PE-8-03B-3796 and PE-9-03B-4083), $515,197.

Lear, Inc., Grand Rapids, Mich., indicators, attitude director, expanded pitch, service test, application, all-cargo type aircraft, (PR PE-8-05C-3770), $32,500.

Aero Instrument Co., Cleveland, Ohio, type AN5816-2 pitot static tubes for supply replenishment spares, (IFB 33-600-59-49, (PR MA-05C-59-163)), $37,245.

The Lewis Engineering Co., Naugatuck, Conn., transmitter, temperature, electrical resistance, type MS24482-2, Aerno 61-2435, IFB 33-600-59-45, (PR MA-05D-112), $73,324.

The Goodyear Tire & Rubber Co., Akron, Ohio, wheels, brakes and spare parts, installation and initial spares for F-105D aircraft, (PR PE-03B-4282), $114,500.

Allison Division, General Motors Corp., Indianapolis, Ind., overhaul, modification and conversion of government owned J33-A-33/33A 33/33A engines to J33-A-41 turboprop engines for TM-61A aircraft, (PR PE 9-02A-4029), $1,734,720.

General Electric Co., West Lynn, Mass., indicator, rate of flow, fuel, type EFU-2/A, Aerno 61-2490; transmitter, rate of flow, fuel, type TRU-6/A, Aerno 61-2491 for use on T-38A and C-133B aircraft, (PR PE-9-05D-3706, PE-9-05D-4188), $502,399.

Lear, Inc., Grand Rapids, Mich., control assemblies, attitude gyroscopic, type AF/A-24G-1, Aerno 60-6312, for use on F-105 and F-106 aircraft, (PR PE-9-05C-4023 and PE-9-05C-4038), $3,175,625.

Standard Coil Products Co., Division, Kollsman Instrument Corp., Elmhurst, N. Y., type ME-4 airspeed and Mach number indicator for F-86H aircraft, (IFB 33-600-59-23), (PR SM-9-05C-2508), $107,250.

Boeing Airplane Co., Wichita, Kans., modify R-224/ARR-36 to R-861/ARR-36 and modify CV-357/A to UG (XA-4/U for VC-137 aircraft, (PR PE-9-16A-4125 and PE-9-16A-4215 and 4215-1), $35,302.

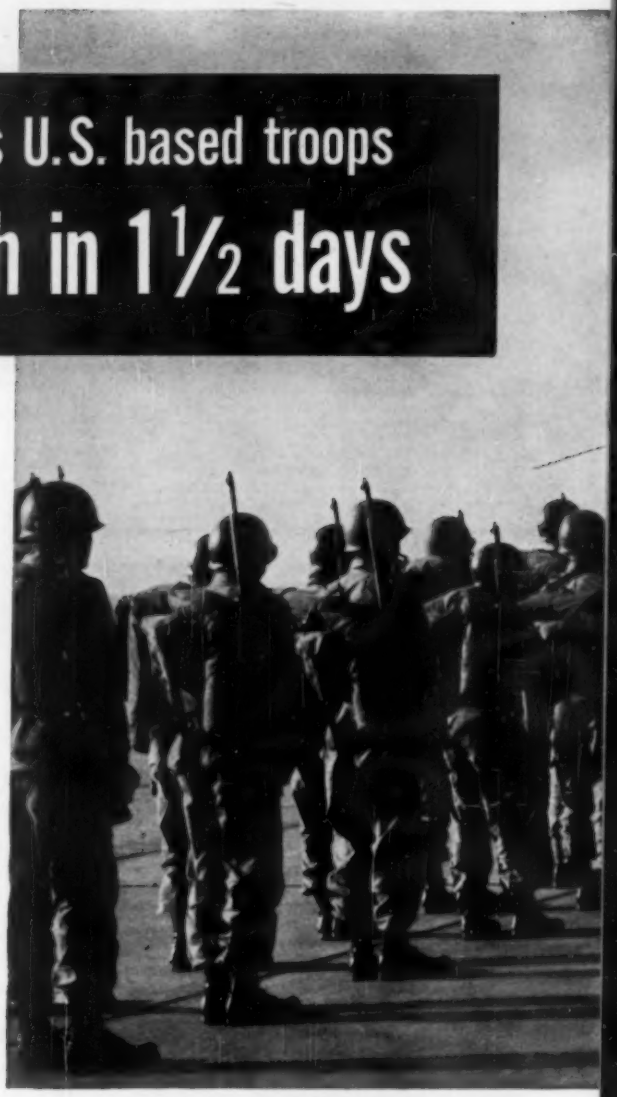
Lockheed's Hercules takes U.S. based troops

Any place on Earth in 1½ days

The Jet Age's first strategic/tactical transport, the new Lockheed C-130B HERCULES, is the only U. S. Air Force plane designed specifically to airlift battle-ready troops, equipment, and supplies from the U. S. to any area on earth in 36 hours or less—then paradrop them into battle zones or land with them on short, rough fields, sand, snow or ice.

The C-130B HERCULES is a huskier, more powerful, longer range version of the C-130A HERCULES—which in two years of world-wide service with the Air Force has become the unchallenged Champion of the U. S. Strategic Airlift.

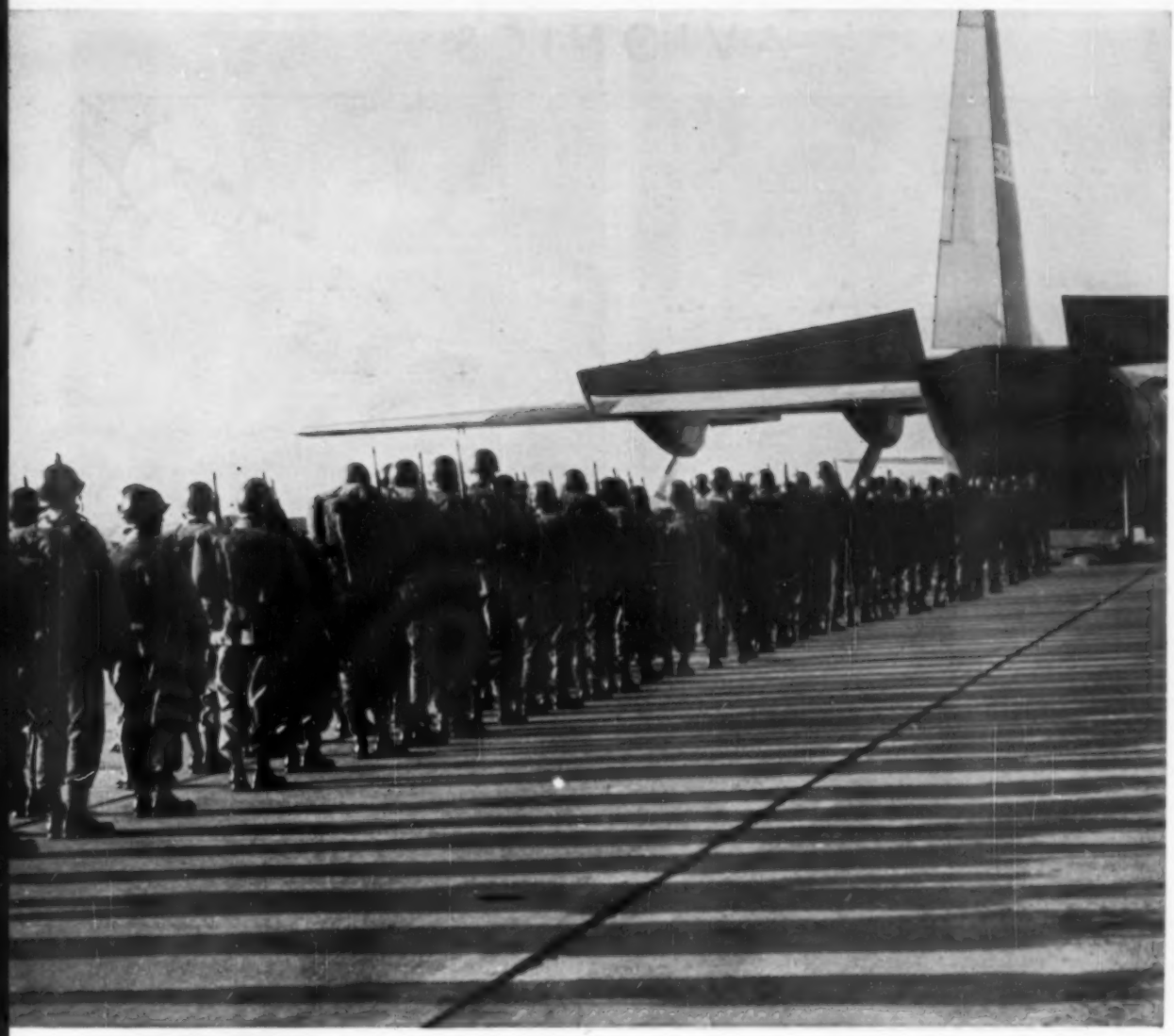
Now coming off production lines at Lockheed's Georgia Division, the new C-130B HERCULES will soon enter service with the U. S. Air Force's Tactical Air Command.



Takeoffs from deep sand averaged only 1500 feet in a C130A at 110,000 pounds gross weight. With same load it landed on sand and stopped in less than 950 feet.

Landing on frozen lake, "Ski-130" (weighing 62 tons gross) stops in 1200 feet. Taking off from same lake, this ski-fitted Airlift Champion was airborne in 2100 feet.

20 tons of pallet-loaded cargo can be winched in or out of the C-130 in 40 seconds. HERCULES can land, unload 20 tons, reload 20 tons, take off in 20 minutes—saving 2½ hours.

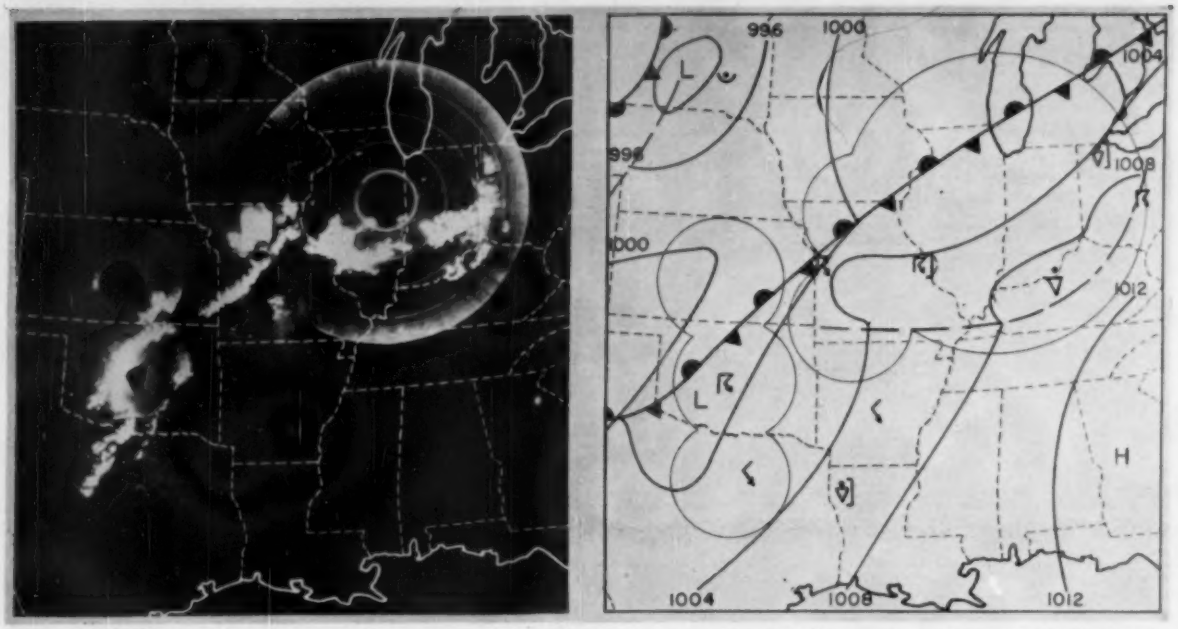


The C-130 HERCULES transports 92 battle-ready troops, or 64 fully-equipped paratroops — and holds the world record for the heaviest parachute-extracted drop: 30,370 pounds.

Challenging opportunities available today for aircraft and nuclear engineers and scientists. *Write: Professional Employment, 834 West Peachtree Street, N. W., Atlanta 8, Georgia.*

LOCKHEED

JET TRANSPORTS • JET FIGHTERS • JET TRAINERS • COMMERCIAL & MILITARY PROP-JET TRANSPORTS • ROCKETRY
BALLISTIC MISSILE RESEARCH & DEVELOPMENT • WEAPONS SYSTEMS MANAGEMENT • ANTI-SUBMARINE PATROL AIRCRAFT
NUCLEAR-POWERED FLIGHT • ADVANCED ELECTRONICS • AIRBORNE EARLY-WARNING AIRCRAFT • AIRPORT MANAGEMENT
NUCLEAR REACTOR DESIGN & DEVELOPMENT • GROUND SUPPORT EQUIPMENT • WORLD-WIDE AIRCRAFT MAINTENANCE



ADVANTAGES of composite radar weather presentation (left) can be seen in comparison with the conventional synoptic display for the same period (right). Synoptic chart shows a stationary front extending from Lake Michigan south into the Texas Panhandle. Radar display shows this to be a series of squall lines in different stages of development, with an old dissipating system oriented east-west. These, and the two other squall line systems shown, compared with the synoptic analysis are clearly ahead of the stationary front analysis. The radar picture also shows that some scattered thunderstorms are organized lines of storms.

U.S. Planning Nationwide Weather Radar

By James A. Fusca

Radar has found a new and important use in the rapidly growing field of radar meteorology. The technique is considered sufficiently promising for aiding faster and more accurate weather forecasting so that Air Force and Weather Bureau scientists are planning the installation of a nationwide network of weather radars and automatic data processing equipment to produce "instant" weather maps covered the entire U. S. The system is expected to be in operation within the next 10 years.

Radar's Value

The value of radar in weather forecasting is that it provides a three dimensional view of the atmosphere in detecting severe storms, precipitation and related weather events. By assembling composite information from a number of radars, large scale weather phenomena such as warm fronts can be viewed and their movements accurately followed.

Radar weather observation will not make obsolete more conventional meteorological instruments such as the radiosonde, barometer, and anenometer, but will supplement them in preparation of forecasts. One important use with both civil and military application is the extremely rapid presentation of storm areas for routing of high speed jet aircraft.

Joint Project

To assist the modernization program designed to integrate existing and proposed weather facilities, a three agency agreement has been reached between the Departmnt of Commerce, for the Weather Bureau, Department of Defense, for the Air Force, and the Federal Aviation Agency that will create both a national and a global weather system.

The program will be under Air Force direction and is designated by the Air Force as the WS 433-L weather system. Air Force part of the system will integrate with its WS 460-L weather reconnaissance aircraft system and WS 480-L global communications system. Bids for the WS 433-L system will be requested within the next two months, and the contract totals by the time the system is completed may reach $500 million.

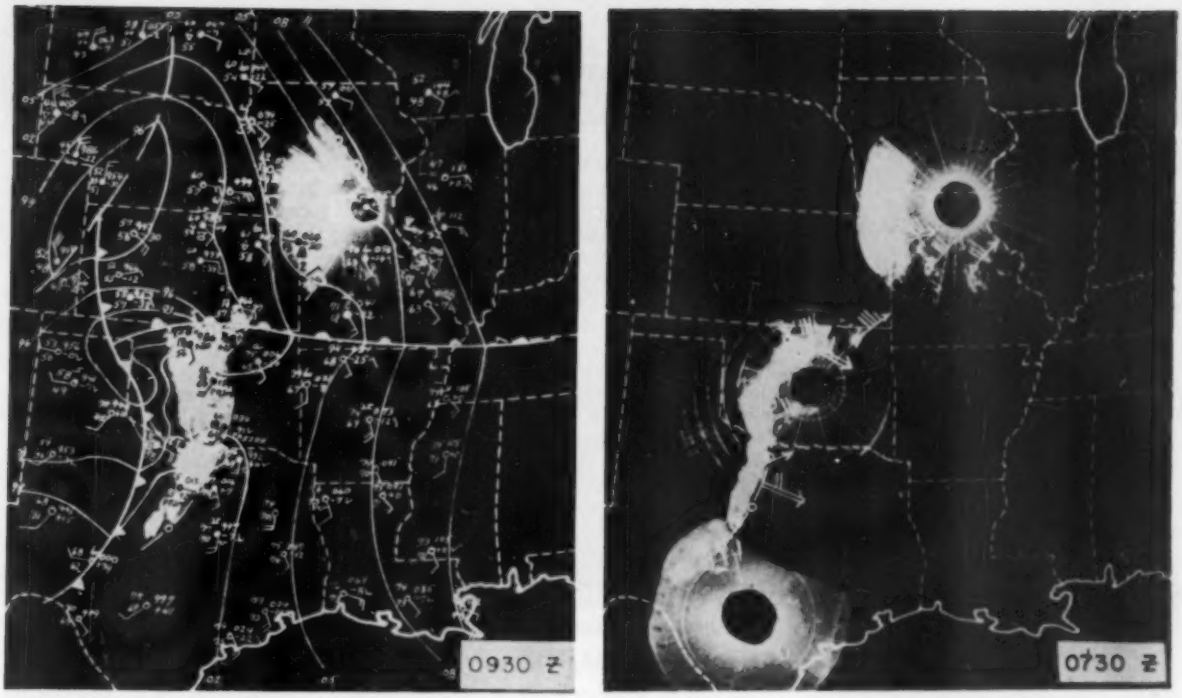
Plan for the WS 433-L system was evolved by scientists at the Air Force Cambridge Research Center to modernize and expand present methods of handling weather information to meet demands by jet aircraft and missiles that require weather data processed far more rapidly than can be done at present. Additionally, the number of weather observations that must be processed is increasing at a rapid rate.

One of the early phases of the WS 433-L program will consist of setting up a test network of nine stations extending from Boston, Mass., to Norfolk, Va. These stations, located at Air Force, Navy, and civilian airbases and airports, will provide an East Coast test sector where equipment and techniques will be checked in operation as they are developed.

Observations from all nine stations will be sent to a "weather central" where synoptic (large area) weather charts will be prepared at intervals as short as an hour apart. This weather central will be the forerunner of a national weather central that will function with the completed national weather system.

System Development

Radar meteorology as a field of scientific study is comparatively young, dating back to World War II when micro-



TWO METHODS of combining radar weather observations with surface synoptic analyses are shown above. Presentation at left shows a plotted and analyzed surface chart upon which the radar plan position indicator displays have been superimposed so the location of precipitation echoes is shown with respect to the frontal systems. In the presentation at right, there are no regular weather observations included, but the motion of the precipitation echoes is obtained from a series of observations shown by means of vectors placed at the proper positions. Direction and speed of elements of the storm echoes are shown.

Network

wave radars first detected echoes from precipitating clouds. Since then, a wide variety of atmospheric phenomena has been identified on radar displays: tornadoes, echoes from lightning strikes, hail, snow, and freezing rain.

Phenomenon of Echoes

More recently, the interesting phenomenon of echoes received from clear air has been identified and studied. Some of these echoes appear to be produced by masses of birds and insects, but the majority are believed to be associated with strong temperature or water vapor gradients occurring at wind shift lines, dry fronts, and thermals.

At present, radar weather stations of the Weather Bureau, Air Force and Navy are used primarily for local operations and forecasts. Hourly reports are sent by teletype to other regional stations, but no provisions exist at this time for assembling and plotting simultaneous observations from widely spaced stations.

Complete radar coverage of the U. S. —except for some western mountain areas not considered essential—will require an estimated 100 stations. As a beginning, the Air Force is presently completing installation of 28 AN/CPS-9 weather radars, and the Weather Bureau has procured about 30 WSR-57 weather radars scheduled for delivery in 1959-60. About five similar radars will be delivered to the Navy.

Practically all phases of radar meteorology are under study at present; much of this work either is sponsored by or conducted by the Air Force. Scientists of the Geophysics Research Directorate, Air Force Cambridge Research Center, have concentrated on problems of cloud physics, using radar observations to explore the manner in which precipitation forms.

Part of this work has included a broad study of identification of severe storms. One result of this study has been the discovery that radar reflectivity of a storm at about the 20,000 ft. level provides an excellent indicator of the storm's severity.

Additional Studies

Other study programs include:

• **MIT Radiation Laboratory.** Scientists at this laboratory have looked into the possible producers of radar echoes in clear air. One possible source they examined was that produced by strong local changes of dielectric gradient. A theory was worked out to indicate how strong the gradient would have to be for a given wavelength. Basic research also has been conducted on the structure and characteristics of storms.

• **McGill University.** Work here has included both basic research on storm characteristics and development of what is called a constant altitude plan-position indicator display. In this presentation, the radar scans at different elevation angles and sections of the scans are assembled to show, for example, conditions between 9,000 and 11,000 ft. or at the 10,000 ft. layer. To do this, radar data must be stored for two to three minutes before being assembled in a single display so the study includes investigation of storage techniques such as memory tubes and fast photography.

• **Stanford Research Institute.** Research

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here is centered about the uses of composite radar pictures. Working with a complete film file, this work will aim to develop techniques for analysis of composite pictures, and suggesting ways in which the composites can be constructed by machines or computers.

• **Texas A & M.** One of the projects underway is a study of storage and readout of radar information. A second is concerned with identification of severe storms by radar. One of the approaches being tried in storage and readout is presentation of a single radar PPI picture on a television type display so that it can be viewed continuously in bright light. An elaboration of this system employs color television, so that radar pictures about 30 min. apart are painted with different color guns—thereby presenting a display that indicates both motion and intensity.

• **Others.** Two specialized but intensive weather radar studies in progress are at the University of Miami, exploring hurricane detection, and the Illinois State Water Survey, measuring rainfall and other hydro-logic applications.

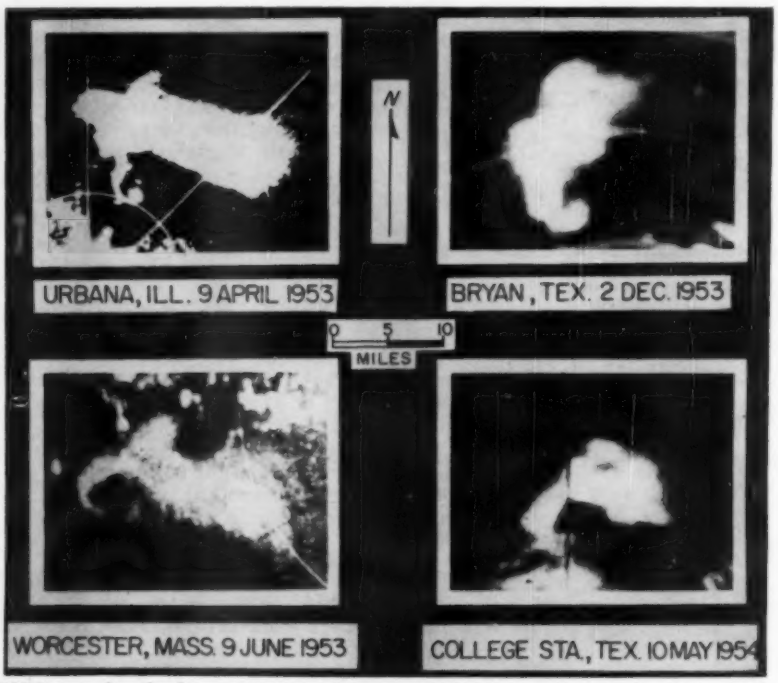
Composite Weather Maps

As part of the development of radar meteorology, researchers have assembled composite radarscope pictures showing weather echoes over hundreds of thousands of square miles. These composite photographs are assembled from dozens of simultaneously exposed pictures of radar plan position indicators showing storm conditions over large areas of the U. S. As a result, meteorologists have found that conventional synoptic weather analysis often fails to provide an accurate and comprehensive picture of the weather. Conventional synoptic maps are prepared on a nationwide basis every six hours. Local stations prepare their own analysis every three hours.

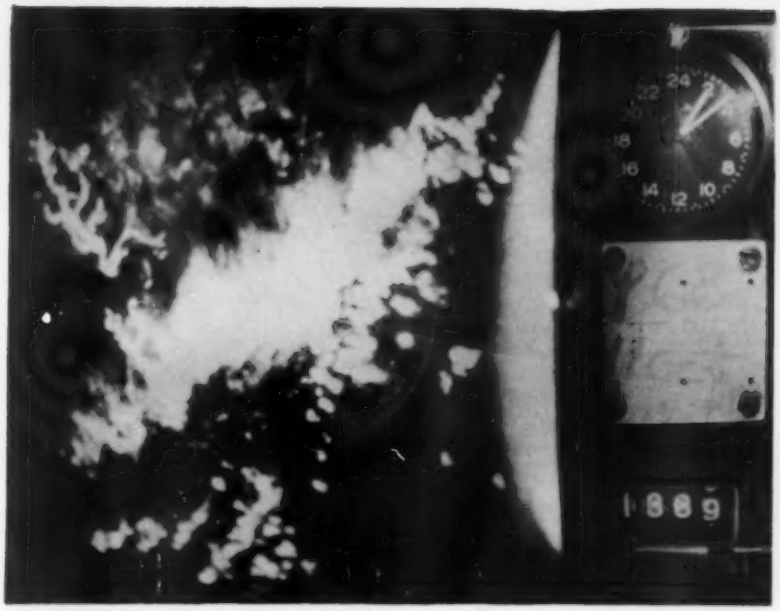
Radar displays, however, are continuous and provide the forecaster with much of the information of maximum interest: time of formation and location of severe storms, storm velocity, storm height, and violence of conditions within the storm. These first studies of composite radar weather maps have indicated the value of the technique and encourage the proposal for a national weather radar network.

A major problem is the storage of data from a nationwide network because it must be acquired simultaneously across the country. It is not feasible for all stations to transmit their information to the weather central simultaneously: more probably it will be sent sequentially. Another problem is bandwidth—the maximum amount of information must be transmitted in the shortest possible time.

There is much information in a radar picture that there would not be time to



FOUR examples of radar precipitation echoes associated with tornadoes, confirmed by visual observation, taken during 1953-54. Two storms, in Bryan and College Station, Tex., were very mild, only slightly more than funnel clouds. Two tornadoes at Urbana, Ill., and Worcester, Mass., were severe. Hook of the echo is the distinctive feature relied upon as the possible tornado storm indicator for warnings in midwest.



LIGHTNING discharge with indicated length of over 100 mi. is shown on weather radar display. Radar echo from the discharge appears as branch-like structure in the upper left part of the scope, extending from the body of the storm toward the north. The discharge took place possibly at 20,000-30,000 ft. above the ground, and traveled through clouds of snow and ice following the snow and freezing rain.

send. A quality picture would take several minutes to transmit, but the number of stations dictates that the data must be transmitted in a few seconds.

Other problems are:

• **Data recovery.** The information must be recovered as it arrives at the weather central, and must be stored for immediate or later printout.

• **Printout form.** The manner and form in which the printout will be made so that the data can be analyzed readily either by humans or computers must be carefully studied.

• **Retransmittal.** Once the data has been collected and analyzed at one central point, the information must be retransmitted to local area forecasters in a form that will be most useful to them for their won analysis. This must be done at relatively high speeds.

One manner in which radar weather maps may be transmitted is in the form of halftone pictures, where a scale of different sized dots might indicate information or they may be in analog or symbolic form where different symbols will indicate different positions, heights and characteristics of the storms.

Because radar observations essentially are continuous, they will be able to detect storms as the storms develop. This is important because storms can develop very rapidly, forming lines over one hundred miles long in less than 30 min. Therefore, the radar gives a more accurate account of where the storm has developed, its extent, and how fast it is moving.

FAA Orders Radar Landing Systems

Washington—Gilfillan Brothers Inc., Los Angeles, has been selected by Federal Aviation Agency to provide a new type ground-based radar system for experimentation in semiautomatic and fully automatic landings. The system, scheduled for delivery late this year, will be installed at National Aviation Facilities Experimental Center (NAFEC) in Atlantic City, N. J.

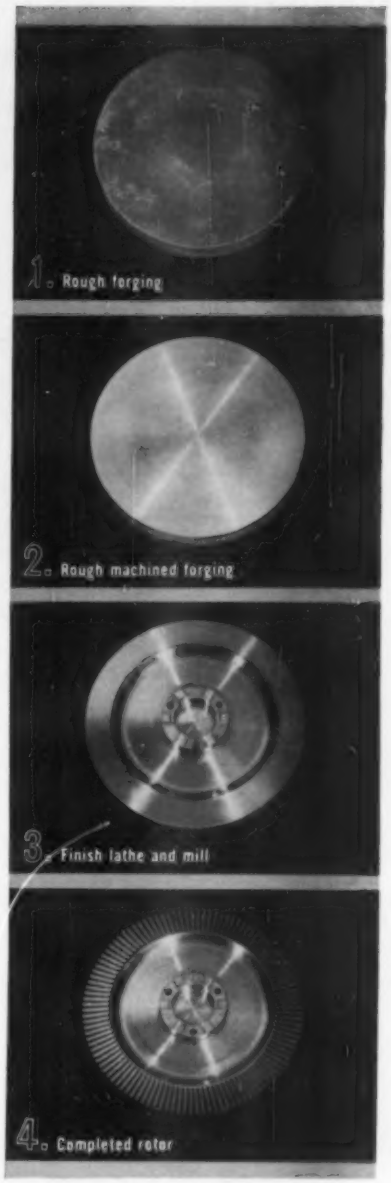
The Gilfillan system, whose development was originally sponsored by Air Force, offers several attractive features:

• **Flexible glide slope:** Unlike ILS, the new Gilfillan system provides essentially an infinite number of different possible approach angles, making it suitable for handling a wide variety of aircraft types including helicopters.

• **Direct cockpit data:** Lightweight unit in the airplane can provide the pilot with direct indication of his azimuth and elevation position as well as distance from the runway.

• **Automatic flight control:** Cockpit derived signals can be fed into autopilot to provide automatic approach and possibly landing, if desired.

Under the $381,446 contract award by FAA's Bureau of Research and Development, Gilfillan will supply experimental equipment providing only elevation position and distance. Equipment will be used to evaluate feasibility of the Gilfillan approach.



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DOUGLAS RB-66A flying testbed touches down at Washington, D. C., after 3 hr. 36 min. nonstop flight from Ontario, Calif., using General Electric CJ805-3 turbojet powerplants. Aerial refueling was not necessary on the 2,295 mi. trip; airspeed averaged 670 mph. Takeoff weight was 70,000 lb., including 30,000 lb. of fuel. Powerplants are identical to those used on Convair 880 jet transports, with exception of sound suppressor and thrust reversers. Pilots were R. J. Scoles, General Electric's chief test pilot, and L. W. Davis, B-66 project test pilot.

CJ805-3 Has Rapid Acceleration Rate

By Richard Sweeney

Edwards AFB—General Electric CJ805-3 turbojet engines, which power the Convair 880 jet transport, effectively demonstrated their qualities in AVIATION WEEK flight evaluation here, installed in the Douglas RB-66A which they recently propelled from Ontario, Calif., to Washington, D. C., in 3 hr. 36 min. (AW Jan. 26, p. 47).

Characteristics of the civil counterpart of the military J79, as noted by AVIATION WEEK pilot while flying the Douglas airframe testbed, were highlighted by:

- **Acceleration from idle** to full power at rates which place this engine in the same response category as a piston engine-propeller or the Allison 501D-13 power packages. Response rate is substantially faster than other turbojets this pilot has flown in various military and commercial jet aircraft.
- **Simple and reliable** air start which, in addition to satisfactory performance within the normal air start envelope, worked satisfactorily at several points well outside the normal envelope.
- **Fuel economy** which, although flows were read from uncalibrated gages, appeared sufficiently better than other turbojets of the same class.

In trying to get an accurate perspective of engine performance and relate it properly to other powerplants, a number of elementary factors were considered which are re-emphasized here due to the margins of difference which were observed in flight evaluation, between CJ805-3 and other 10,000 lb. thrust class jet engines.

Turbojets are not supposed to have the same propulsive efficiency at low speeds and altitudes as propellers (driven by reciprocating or turbine engines).

Thrust/Weight Ratio

Thrust/weight ratio of testbed, aerodynamic characteristics of the airframe, the airframe-propulsion system dynamics all contribute to the over-all impressions given by the flight test vehicle.

Testbed is first RB-66A built by Douglas Aircraft, was used in USAF Phase II flight test at Edwards and is leased by General Electric for the strictly commercial CJ805-3 program, rather than bailed.

Besides removal of much combat gear, the aircraft was modified for the CJ805-3 program in two ways—production engines, in pods designed and built by Convair which are almost identical in inlet configuration to 880 pods, are installed; the electrical system was changed to incorporate the General Electric constant speed drives and alternators which are featured on the 880 (AW Sept. 8, 1957, p. 50). Thus the testbed incorporates powerplants and primary electrical system components which will be used on the commercial transport.

The RB-66A is basically a non-instrumented testbed and is intended for flying in a generalized program similar to endurance work which Lockheed Aircraft accomplished with Electra power packages in Elation (AW Oct. 14, 1957, p. 93), and Allison "Operation Hourglass."

The testbed does not incorporate the General Electric sound suppressors with which the 880 now is equipped and carried on first flight, nor are thrust reversers installed.

Two flights were made in the AVIATION WEEK evaluation program, with the main effort directed toward sampling the CJ805-3 features which have gained widest attention, primarily acceleration and air relights, plus fuel consumption, although accurate fuel consumption measurement at the various altitudes was precluded by the lack of proper instrumentation that was noted earlier.

In the acceleration regimes, various throttle displacements, at varying rates, were made at a number of altitudes,

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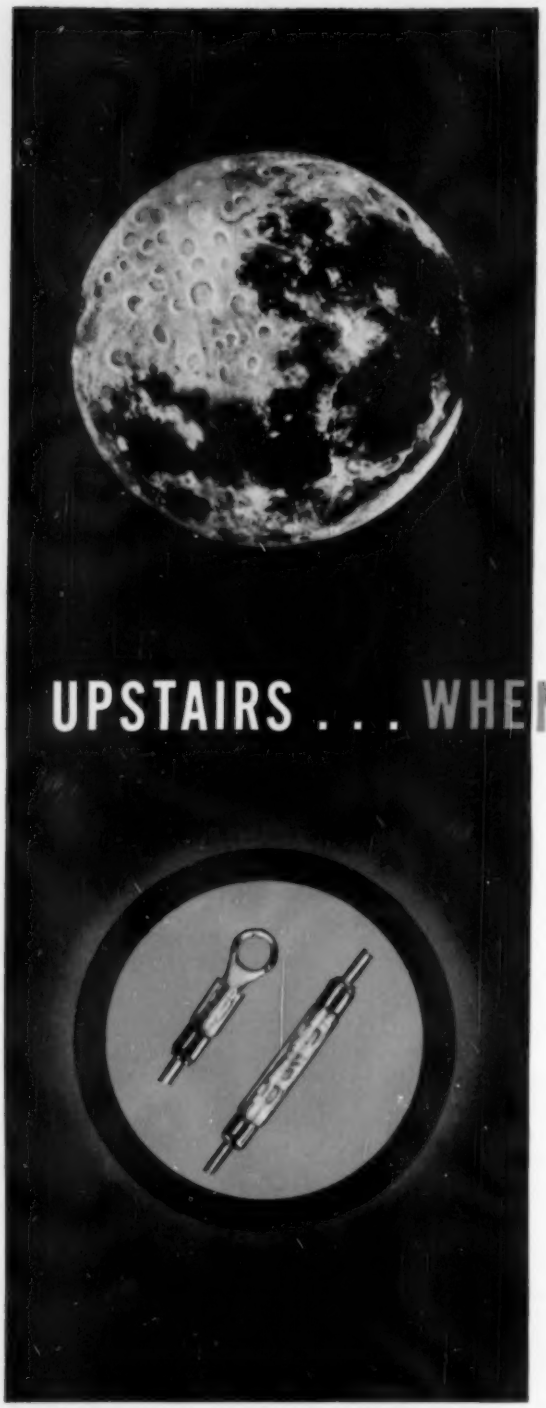

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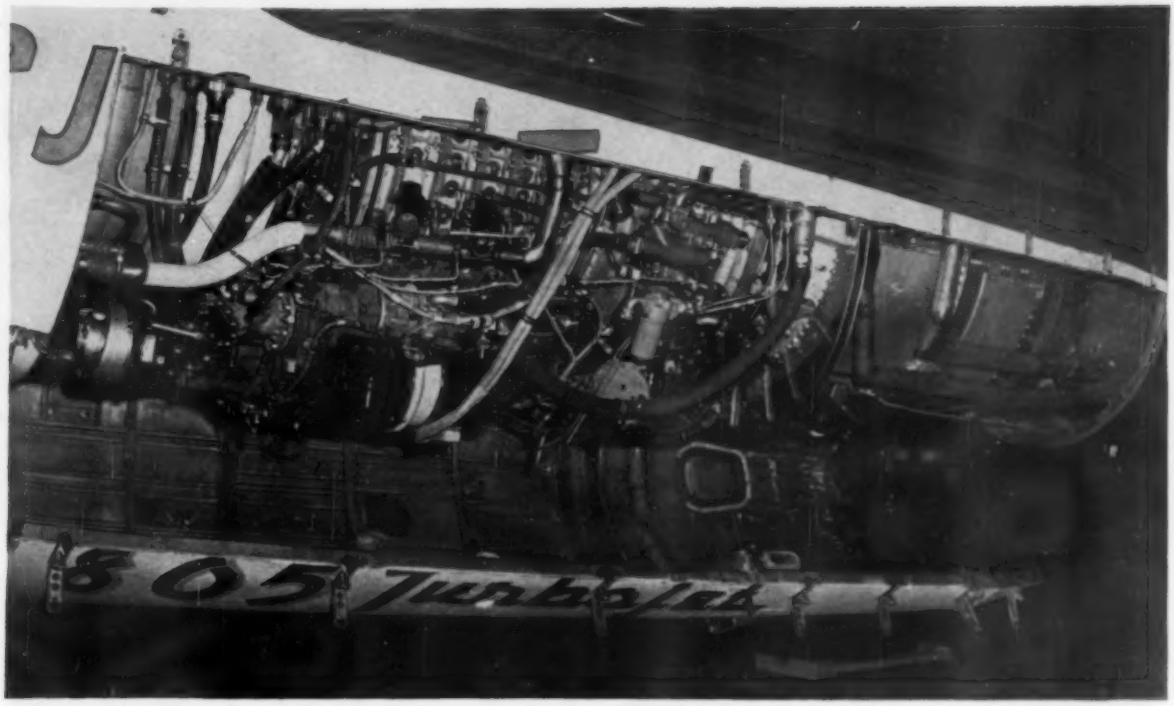


CJ805-3 engine pods are similar to those on the Convair 880 turbojet transport. Builtup portion at top is testbed beefup.

especially at high and low altitudes. Additionally, air starts were run through at altitudes from 13,500 ft. to 41,500 ft.

Additional acceleration examples were obtained in ILS missed approach runs at Oxnard Air Force Base.

CJ805-3 acceleration in takeoff position showed thrust rise to be virtually simultaneous with rapid throttle application. Testbed limitations preclude full power at a standstill, instead power is stabilized at 93% rpm., roll is started and full power applied after speed is gained.

Thrust Buildup

In adding the last increment of power, thrust buildup was simultaneous with throttle movement. In the first and second segment climb, 100% rpm for full 5 min. allowable period was maintained. Takeoff was dry—neither J79 nor CJ805 are designed for water injection.

ILS approaches were made with gear down, flaps at approach (60%) and speed brakes extended, with full flap extended just prior to reaching the middle marker. Airspeed was at recommended value for existing gross weight. The first approach was made with altitude held above the glide slope until close in, giving a steeper descent and faster rate of descent than would normally obtain, while the second approach was held to the proper glide slope angle. In both approaches, aircraft was flown somewhat beyond the usual simulated ILS waveoff minimum, to ascertain engine acceleration and thrust buildup relationship when power is applied for go-around late in an approach.

Full power was applied from 68% rpm., approximate best power level for RB-66A approach in existing configuration, and acceleration was simultaneous with very rapid throttle movement. Testbed acceleration was fast enough that despite immediate gear retraction, the speed built up too fast for wheel doors to complete their closure cycle properly, even with speed brakes remaining extended.

A standard airline missed approach profile was followed rather than a high angle pullup which would have held the speed down. Testbed was at light gross weight—on the order of 46,000 lb., which gave a very good thrust/weight ratio.

Engine Performance

Engine performance through both waveoffs was satisfactory. The testbed accelerated swiftly from an airspeed bordering on V_s plus 10 kt. with a high angle of attack, completely dirty configuration, giving rise to the opinion that reaction is almost equal to a propeller propulsion systems.

Throttles were chopped, slammed forward and generally severely abused according to usual engine handling standards. No surges or compressor stalls resulted from the sampling, done at various altitudes and airspeeds.

Air starts with CJ805-3 are accomplished very simply in three operations —turn on fuel boost pump, air start (ignition) switch and fuel control. Engines come from windmill to idle swiftly and smoothly.

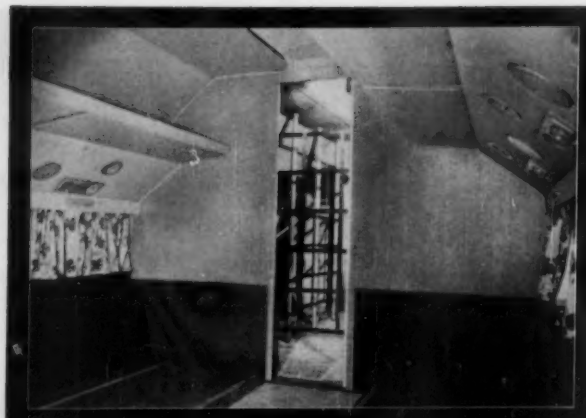
Starts were made in flight evaluation above the normal restart altitude and below normal airspeed. In all cases, the powerplant successfully relighted, regardless of windmill speed (down to 21% rpm. or airspeed (as low as 205 kt., indicated air speed at restart initiation altitude of 41,500 ft. in one case).

Single Engine Test

In the testbed, altitude could not be maintained on one engine at the average weight of 48,000 to 52,000 lb. at which several high altitude starts were accomplished. In these cases, after the engine had windmilled down to below 30% rpm., the altitude had slipped to about 37,500 ft. at which time a relight was fully accomplished and the engine was returned to the flight power setting.

One airstart was accomplished at 40,000 ft. with ignition and relight initiated at 40% rpm. at 186 kt. IAS (Mach .58), a somewhat low speed for the altitude. Little altitude was lost since the engine was not allowed to spin down to low speeds, a time consuming process.

Both engines were relighted at 35,000 ft. at 40% and 41% rpm., both at 180 kt. (Mach .55), with fuel flow on one coming to 525 lb./hr., the other to 500



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lb./hr., and exhaust gas temperature (EGT) held at 450C and 460C.

In almost all cases, fuel flows at restart idle speeds remained within plus or minus 25 lb. of the 500 lb./hr. value, and EGT peaks at relight stayed between 450C and 500C, although the majority were at the level of 450 to 460C.

A component of the CJ805-3 which gets much credit for engine's performance is the Woodward fuel control. Among the features of this control is a capability of the engine to be restarted with the throttle set at any position from idle to full thrust at any altitude or airspeed.

One such start was demonstrated, in which the throttle was left at full open position when the fuel was shut off. To lessen thermal shock which would have been incurred if the engine had been allowed to cool completely during the time period required for windmill down to about 20% rpm., the engine was restarted at about 40% rpm. Relight was normal and the engine moved to idle rpm. of about 65% (proper for the altitude) where acceleration fuel flow schedule came in and engine quickly and smoothly moved to 98% rpm. which was full throttle value for the altitude. There was no overspeed or hunting.

Several similar examples were accomplished by the AVIATION WEEK pilot, with throttles set at 92% rpm. at 15,000 ft. In several such situations, in which engines were allowed to idle down to about 21% rpm. at airspeeds at 186 to 192 kt. IAS (Mach .382), relight was accomplished satisfactorily. At the lower altitudes and less than maximum power settings, thermal shock was not as severe as would have obtained at higher altitudes and lower temperatures, since outside air temperature at the time registered zero Centigrade.

In the Woodward controls, a corrected speed cutback is incorporated which prevents compressor stalls and engine surges which might easily be obtained with inadvertent throttle bursts and high throttle setting air restarts.

Examples of these were done in AVIATION WEEK flight evaluation.

This feature uses four control parameters, compressor discharge pressure, compressor inlet temperature, actual rpm. and throttle position. The unit, essentially an anticipator, functioned to start reducing fuel flow to prevent overshoot and hunting as the rpm. approaches the value called for by the throttle setting. It works in reverse on a throttle chop—preventing stall from sudden fuel starvation condition.

As is any turbojet, the CJ805-3 is designed for a certain mass air flow, which is subject to change according to altitude and temperature. To obtain desired mass air flow, or as close to it as possible, the engine incorporates a corrected engine speed feature, an automatic compensation for altitude and temperature changes.

The unit works to provide the value of flow which would be the proper level at the selected rpm. (throttle setting) and altitude on a standard day. When temperature is below normal, the actual engine rpm. drops since proper air mass flow is obtained with less engine speed. On a hot day, actual engine speed is greater to make up for the less dense air and still provide the proper or best obtainable mass air flow.

Optimum Mass Flow

Readout on the pilot's instrument panel is the proper hypothetical engine speed for the altitude and temperature, although actual rpm. may be higher. For example, on a hot day at 37,000 ft., the instrument panel tachometer may read 96% rpm. while the actual engine speed is 104% rpm., maximum limit speed for the engine. This will produce the optimum mass flow, either the value desired or the closest possible for the altitude and temperature.

The CJ805-3 is essentially a J79-7 powerplant, (AW Aug. 11, p. 69), the Phase II development stage. However, it has no afterburner, but the weight is absorbed in other areas in beefing up the engine's structure for longer service periods between overhauls for commercial certification. One area of difference is that while the J79-7 uses magthorium in part of compressor case, the CJ805-3 uses a steel case. There is additional structural reinforcement in areas where longer service life will mean reduced maintenance cost, where weight is not the same criterion it is in a military powerplant.

The current CJ805 program got under way about a year ago when the airplane was leased and then went into the modification cycle. Scheduled to fly in October of last year, its first flight on the modified testbed was made at 4:30 p.m., Oct. 31. Following 10 quick hours of shakedown, the testbed was delivered to Douglas Aircraft at Long Beach for shake test. It was returned to General Electric in December.

General Electric is tailoring the Edwards AFB flight program to provide as close a simulation as possible of airline type schedules. Flight schedules were outlined after conferences with airline operators who have purchased the Convair 880 with CJ805-3s.

While one engine in the RB-66A is partially instrumented, a fully instrumented CJ805-3 is installed in the Douglas XF4D which General Electric operates as a testbed. Engineering test data is derived from this aircraft, which uses an oscillograph and photo panel data gathering system. CJ805-3 first flew last April in the Skyray, flew 100 hr. in 3½ weeks, then went to Convair for ground runs and testing there. Another CJ805-3 was installed in the XF4D last September.

In the RB-66A, current engines have accumulated quite a few hours. However, about Mar. 1, an engine will be installed which already has been run 1,000 hr. on test stand at General Electric plant in Evendale, O. This powerplant will be run another 1,000 hr. in the RB-66A, it is hoped by October of this year.

Goal of this program is to raise

First Grumman Mohawk Nears Completion

First Grumman Mohawk turboprop Army observation plane is nearly completed on Grumman's production line at Bethpage, N. Y. Army will spend $22 million for 35 Mohawks, as follow-on to a contract awarded last April for construction of nine prototypes which will be tested and evaluated by Navy Bureau of Aeronautics. Navy is administering Mohawk contracts for the Army. Short takeoff and landing aircraft, designed to operate from small, unimproved fields, is powered by two Lycoming T53-L-3 turboprop engines, each rated at 1,005 eshp. Mohawk has tricycle landing gear; weighs 9,000 lb. empty and has wingspan of 42 ft. Over-all length is 41 ft. Army designation will be AO-1AF.

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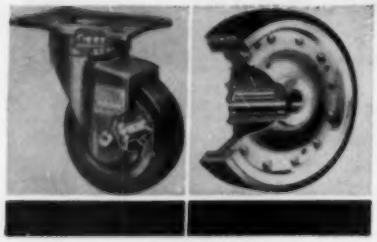

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time between overhauls to 1,000 hr. for the engine, if possible before the powerplants enter commercial service. Additionally, it will give General Electric a good idea of the problems to be encountered through service life of engines after they have passed the first 1,000 hr. mark.

Testbed also is to be equipped with the same engine gages which will be used on the production 880s, to get an idea of compatibility of powerplants and instrumentation.

So far the testbed has been flown by General Electric and Convair pilots, plus AVIATION WEEK pilot. Don Germeraad, 880 test pilot, flew the testbed before the first 880 flight, sampling engine performance, air starting characteristics and possible compressor stall at altitude.

Convair will be sending pilots to the General Electric Edwards facility, two at a time, during the remainder of the program both to help with the flying and to gain familiarity with the powerplants and electrical system components.

Napier Inaugurates Canadian Subsidiary

London—British aircraft and diesel engine maker D. Napier and Son Ltd., part of the English Electric group of companies, has formed a Canadian subsidiary, D. Napier and Son (Canada) Ltd. to increase trade with Canada.

New subsidiary will sell, overhaul and service all Napier engines including the "Deltic" diesel, marine and industrial gas turbines, and the Eland turbojet engine which is installed in the military and civil versions of the Canadair 540 aircraft. Company also will handle conversion of piston-engined Convair 440 airliners to Eland engines, civil and military applications of helicopter gas turbines, rocket engines and the "Spraymat" aircraft de-icing system. Headquarters of the new company is at 4104 St. Catherine St. West, Montreal.

Ministry Airplanes Get Fluorescent Paint

London—Britain's Ministry of Transport and Civil Aviation is painting fluorescent orange markings on its fleet of 15 aircraft used for testing pilots and equipment. It is hoped to persuade airline operators to do likewise, as an aid against midair collisions.

Independent airline Hunting Clan Ltd. has announced it will paint its fleet of 17 aircraft fluorescent "rocket red." British Overseas Airways Corp. says it is "examining possibilities" of using this paint on its fleet.

Jet Plane Facilities Readied at Seattle

Seattle, Wash.—An addition to the administration building at the Seattle-Tacoma International Airport should be ready for use in April, according to George T. Treadwell, chief engineer for the Port of Seattle, airport operators.

A 500-ft. long wing will provide additional passenger-deplaning and gate facilities, with three positions for jet planes and one for piston-engined transports. A 270-ft. vehicle parking lot in front of the wing is designed to relieve congestion in existing lots.

British Companies Form Nuclear Group

London—Three major British companies, Rolls-Royce, Vickers, and Foster Wheeler, have formed a new company, Rolls-Royce and Associates, to design and build nuclear power equipment.

All three already are collaborating on developing a nuclear submarine.

New company plans to be active in every field of nuclear power, including nuclear propulsion of aircraft, rockets, ships and automobiles, officials said.

Rolls-Royce holds 52% of the $700,000 initial capital.

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SUNDSTRAND AVIATION

Navy Revises Security Plan to Cut Costs

By Philip J. Klass

Washington—Fundamentally new security classification policy has been established by the Navy Bureau of Aeronautics in an effort to strip away red tape that has hamstrung both BuAer and its contractors and added unnecessary cost to defense procurement.

New security classification policy, which has been tried out with about a dozen contractors, will go into effect for all of BuAer's 10,000 contractors within the near future, probably within the next several months.

Bureau of Aeronautics' new policy operates within the framework of Defense Department's Security Requirements Check List (DD Form 254), devised in 1952 as a means of advising defense contractors what security classification should be applied to various phases of a program. Within this framework, however, BuAer has applied a new "common-sense" philosophy to what should or should not be classified.

The new security classification criteria will result in the downgrading and declassification of many items now under contract or in fleet use. However, BuAer expects that the net result will be a major improvement in the safeguarding of vital military information. One Bureau of Aeronautics spokesman puts it this way: "By eliminating the trivia which we and the contractor know is not justifiably classified, we expect to gain more respect for real security information and better protection for what needs to be kept secret."

Planned Achievements

In addition, when the new policy is fully implemented, BuAer expects to:

- **Save sizable portion of money** now spent for special handling and guarding of equipment, components, drawings and report which in themselves are not of value to an enemy.
- **Provide realistic guidelines** that will enable local Navy plant representatives and contractors to quickly determine the proper security classification for any piece of equipment, hardware or literature.
- **Simplify subcontracting of defense** work, particularly to small business, by eliminating the need for manufacturing non-critical devices and subsystems in a guarded classified area with all the attendant constraints.

The basic philosophy behind BuAer's new program is that the object of security classification should be to withhold military information of value to an enemy and that such things as configuration, equipment design, drawings, models and reports should be classified only to serve this purpose as opposed to the cornerstone of security classification philosophy in some circles that any details must somehow be of a value to an enemy.

For example, in the past when a contract was placed for development of a new radar, the entire equipment and its elements usually were classified despite the fact that many of its component parts might be commercially available on an unclassified basis and many of its techniques might be well known.

From the enemy's viewpoint, what he wants to know about a new radar in order to jam it is its operating frequency, its ability to rapidly change frequency, its pulse encoding techniques and its vulnerability to electronic countermeasures. This is the type of information that the bureau proposes to classify—not the dimensions of the box the radar indictor is housed in or the finish on the threads of the bolts in the antenna pedestal.

Classification Criteria

Instead of instructing a contractor that all drawings of test equipment, or all external views or all design details are classified "confidential" or "secret" as in the past, each item will have its own individual classification, including "unclassified," depending upon whether or not it reveals military performance or operating characteristics of value to an enemy.

BuAer has added a fifth page to the standard DD-254 security check list in which it lists 20 different types of significant military performance/operating characteristics information, one or more of which may be applicable to any specific contract. For each of these types of information, BuAer assigns a classification category ranging from "top secret" to "unclassified."

Types of information which apply primarily to aircraft and missiles include on-station time, speed limits and restrictions, altitude limitations, range limitations, maneuverability, armament installation and accuracy. For powerplant programs, categories include specific thrust, specific fuel consumption.

Types of information listed for avionic equipment include effectiveness of countermeasures, vulnerability to countermeasures, maximum depth above or below water for satisfactory operation, sensitivity, speed of computation, coding, specific frequency, bandwidth and frequency shifting capability. Final item listed is tactical application. Other special listings can be typed in as required for special situations.

Bureau of Aeronautics has formulated uniform criteria for establishing what classification should be applied to each type of airplane, missile, helicopter and avionic equipment, depending upon the particular stage in its life cycle, i.e. development through fleet use and finally obsolescence.

Typical Application

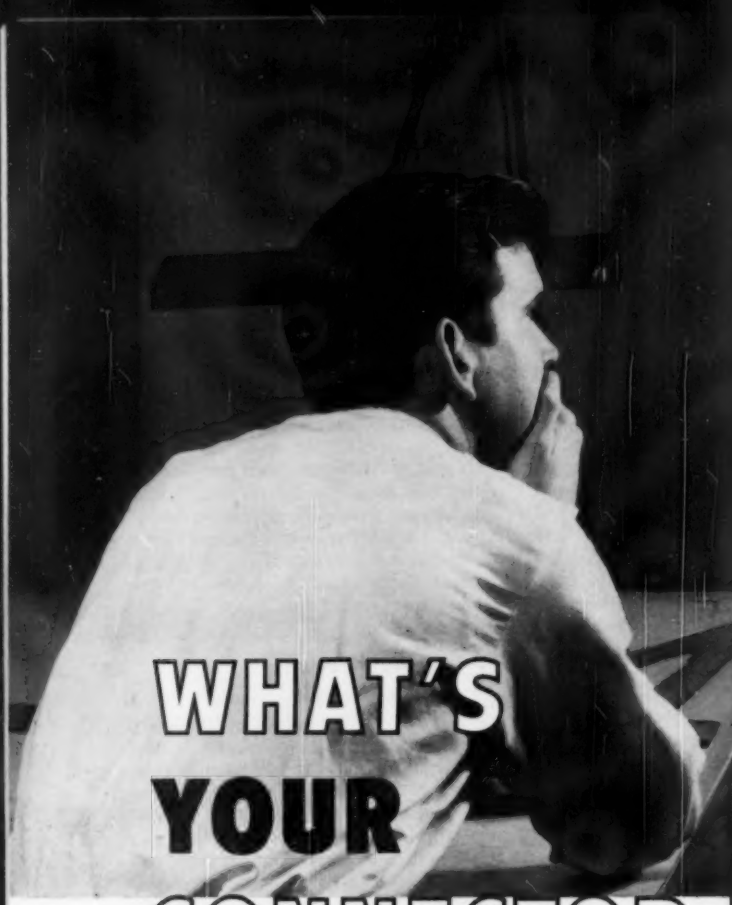
Using the previous example of a search radar, both the general frequency band (i.e. X-band, L-band, etc.), and the specific operating frequency within that band would be classified "confidential" during development and experimental model fabrication. But when the equipment is ready for flight testing, the general frequency band becomes unclassified, but the specific frequency within this band remains "confidential." This is a practical viewpoint inasmuch as the size of radar waveguide, which may be seen by many persons during flight tests, reveals the frequency band but not the specific operating frequency in that band.

This means, for example, that during production (when same classifications apply), the radar set manufacturer need not classify the drawings, specifications or test equipment for waveguides since their size, configuration and characteristics do not reveal the specific operating frequency, only the general band, which is unclassified.

Similarly, the radar display console also might be handled on an unclassified basis throughout design, manufacture and test, except possibly for the nameplates which may reveal information on the radar's range and anti-countermeasures capability.

As result of this new BuAer policy, many of the components of a new system can be shipped without the elaborate security measures that formerly required a sealed boxcar and/or armed guards.

Applying the new philosophy to a new Navy airplane recently saved the bureau close to half a million dollars When the aircraft was ready to be rollec out of the contractor's factory, the air frame configuration was still classified The contractor therefore requested ap-



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proximately $500,000 to build a structure to shield the plane from public view. After looking into the matter, BuAer and the contractor agreed that the only significant feature which needed to be kept secret was the shape of the engine air inlets. This could be accomplished by building an inexpensive structure for masking the inlets at a cost of a few thousand dollars.

With the new explicit, clear-cut delineation of what constitutes classified information, BuAer expects to greatly reduce the hundreds of requests for interpretation which previously had to come to headquarters for a decision, according to Paul Kauffmann. Kauffmann is assistant to BuAer's security director for classification.

For instance, certain classified equipment must either be placed under 24-hr. guard or else removed from an airplane for security. Recently, the question came in from a Navy field facility: "When we pull out the equipment, must we also remove all of the airplane wiring which interconnects elements of the equipment?" Under the old policy, the cables might be considered part of the classified equipment. But under the new security guidelines, it only is necessary to establish whether the cables could by themselves reveal specifically useful information about the classified equipment.

Avionics Back-Breaker

Instead of applying the new philosophy only to new contracts, BuAer decided to apply it to existing programs and equipments now in fleet use. Toughest part of this retroactive analysis came in BuAer's Avionics Division, where some 10,000 equipments and programs had to be reclassified using the newly established criteria. The program was spearheaded by William Gregory, working with Kauffmann's office. Some of the equipments had been developed during World War II, still carried a security classification because no one had gotten around to declassifying them. Approximately 2,000 items were declassified, a number of others downgraded.

BuAer considered reclassification of individual subassemblies and spare parts for existing equipments in accordance with the new criteria but found the task too overwhelming, with more than 100,000 items that would have required detailed study.

Therefore, BuAer will establish security classification levels for subassemblies and spare parts only on future contracts. This will be done concurrently with spare parts provisioning. Each contractor will be responsible for recommending security classification for individual spare parts, but recommendations will be reviewed by the BuAer security director. Gregory believes that the bulk of the spare parts will be unclassified.

Within the next several months, the bureau expects to publish a new BuAer Classification Guide book which will list every one of its contracts and indicate the new classification category which applies to each. Once every six months each of the classified programs will be reviewed with the appropriate project engineer to establish whether any change in life-cycle category has taken place. If so, a new security category will be listed in the next edition of the Classification Guide which will be published twice a year.

When the first new Classification Guide becomes available in the next several months, BuAer will then extend its new policy to all of its contractors.

AIRPORT REQUIREMENTS†

	Air Commerce Airports*	General Aviation Airports*	Total Needs*	Federal Aid Under Monroney Bill†	Administration Bill†
Ala.	$17,569,000	4,494,000	$22,063,000	$6,619,755	$1,675,816
Ariz.	17,215,000	5,139,000	22,354,000	7,438,055	1,745,488
Ark.	1,907,000	3,608,000	5,515,000	5,311,590	1,316,689
Calif.	158,997,000	41,997,000	200,994,000	21,644,950	5,508,885
Colo.	26,182,000	4,126,000	30,308,000	7,562,545	1,803,467
Conn.	7,603,000	4,900,000	12,503,000	2,693,695	720,823
Dela.	2,161,000	832,000	2,993,000	514,430	134,325
D. C.	.....	.....	.....	952,150	259,525
Fla.	15,540,000	2,183,000	17,723,000	6,743,865	1,689,461
Ga.	19,825,000	2,756,000	22,581,000	7,460,815	1,888,417
Idaho	4,866,000	1,088,000	5,954,000	5,501,970	1,292,891
Ill.	77,779,000	15,036,000	92,815,000	13,629,735	3,573,470
Ind.	3,756,000	6,595,000	10,351,000	6,750,845	1,750,483
Iowa	4,855,000	4,453,000	9,308,000	6,335,920	1,588,151
Kans.	7,279,000	5,316,000	12,595,000	6,984,585	1,700,461
Ky.	17,637,000	6,128,000	23,785,000	5,804,290	1,482,675
La.	20,459,000	14,670,000	35,129,000	6,021,410	1,519,157
Me.	7,459,000	2,358,000	9,817,000	3,053,995	747,646
Md.	22,406,000	6,830,000	29,236,000	3,477,105	917,788
Mass.	32,166,000	10,320,000	42,486,000	6,074,310	1,633,852
Mich.	22,849,000	3,263,000	26,112,000	13,098,870	3,332,038
Minn.	18,464,000	4,825,000	23,289,000	8,488,135	2,100,596
Miss.	13,445,000	5,963,000	19,408,000	5,352,090	1,339,750
Mo.	19,686,000	6,144,000	25,830,000	8,682,060	2,194,782
Mont.	8,372,000	1,516,000	9,888,000	9,161,965	2,133,058
Nebr.	13,721,000	2,040,000	15,761,000	6,008,850	1,546,885
Nev.	5,975,000	190,000	6,165,000	6,547,475	1,510,960
N. C.	9,319,000	3,720,000	13,039,000	7,833,210	2,005,435
N. D.	3,380,000	2,086,000	5,466,000	4,797,065	1,132,685
N. H.	3,094,000	1,957,000	5,051,000	1,165,460	294,744
N. J.	25,081,000	5,031,000	30,112,000	6,188,195	1,667,390
N. Mex.	12,036,000	2,276,000	14,312,000	7,803,390	1,825,846
N. Y.	94,402,000	12,374,000	106,776,000	20,632,675	5,493,402
Ohio	26,969,000	8,516,000	35,485,000	11,962,885	3,151,776
Okla.	16,680,000	5,254,000	21,934,000	6,661,570	1,643,084
Ore.	8,535,000	1,124,000	9,659,000	7,379,340	1,771,444
Pa.	66,151,000	14,613,000	80,764,000	15,058,530	3,992,660
R. I.	3,828,000	660,000	4,488,000	1,006,660	271,513
S. C.	6,355,000	2,789,000	9,144,000	4,296,555	1,094,322
S. D.	5,718,000	1,219,000	6,937,000	5,203,280	1,227,612
Tenn.	12,660,000	6,450,000	19,110,000	6,320,700	1,618,928
Tex.	30,375,000	12,188,000	42,563,000	24,492,400	6,015,527
Utah	6,978,000	1,048,000	8,026,000	5,698,605	1,343,145
Vt.	2,283,000	2,386,000	4,669,000	999,210	248,640
Va.	4,667,000	11,519,000	16,186,000	6,357,285	1,628,703
Wash.	13,724,000	2,371,000	18,095,000	6,872,225	1,698,875
W. Va.	6,911,000	3,950,000	10,861,000	3,761,460	965,810
Wis.	16,630,000	6,502,000	23,132,000	7,868,425	1,981,461
Wyo.	3,996,000	1,448,000	5,444,000	5,975,415	1,386,325
Sub Totals	$949,965,000	$276,251,000	$1,226,216,000	$356,250,000	$97,250,000
Alaska	$36,444,000	$1,327,000	$37,771,000	$11,250,000	$7,783,134
Hawaii	18,959,000	931,000	19,890,000	6,250,000	2,750,000
P. R.	9,240,000	873,000	10,113,000	5,000,000	1,925,000
V. I.	5,705,000	.....	5,705,000	2,500,000	825,000
Sub Totals	$70,348,000	$3,131,000	73,479,000	$25,000,000	$13,283,134
Discretionary Funds	.....	.....	.....	193,750,000	97,250,000
Totals	$1,020,313,000	$279,382,000	$1,299,695,000	$575,000,000	$200,000,000

† Computation by staff of Senate Commerce Committee
* From survey by Federal Aviation Agency

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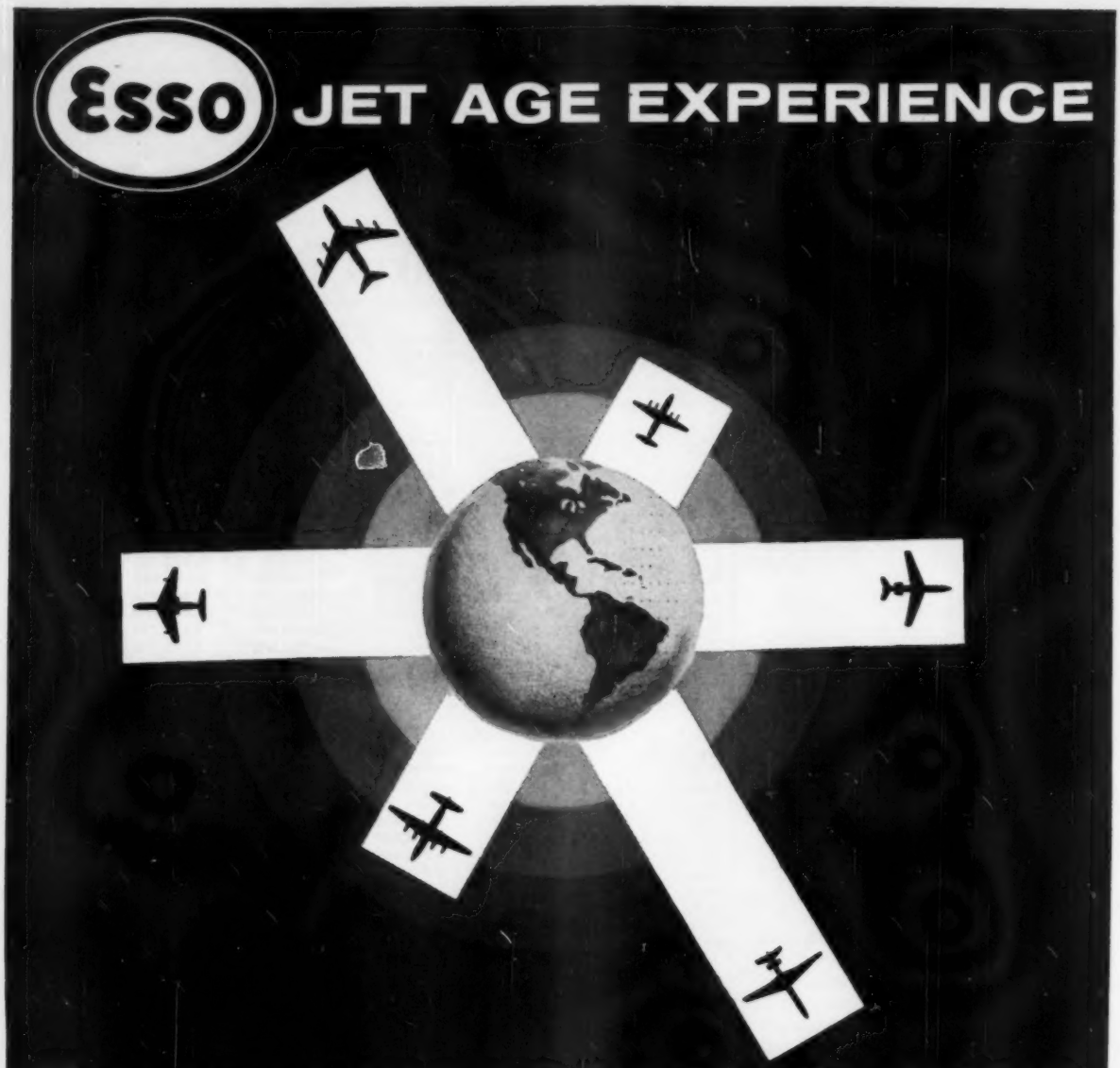

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AVIATION PRODUCTS

Fuel Unit Would Prevent Contamination

Sewaren, N. J.—Long range goal of a research program underway at the Shell Oil Co.'s Aeroshell Turbine Fuel Equipment Laboratory here is a fail-safe unit that will automatically shut off the pump on a refueling wagon to prevent contaminated fuel from entering sensitive turbine engines.

This goal is admittedly a distant one; major reason for this is the extremely small size of the solid contaminants the fuel experts hope to stop. Five microns is tentatively set as the upper limit for admissible particles. A photoelectric beam, which was the basis of one attempt at a fail-safe unit, proved too crude to handle the problem.

A more immediate objective is the development of a filter-separator that will remove contaminants selectively. There is no filtering unit available today, Shell declares, that alters particle size distribution. A good filter may remove 99% of the foreign particles from aviation fuel, but those that are left will range in size from 1 to 150 microns. What is needed is a filter-separator which will take out all contaminants above, say, 10 microns without slowing the fuel pumping rate. This would be a significant step. Meanwhile, Shell and others are investigating supplemental, positive cut-off devices.

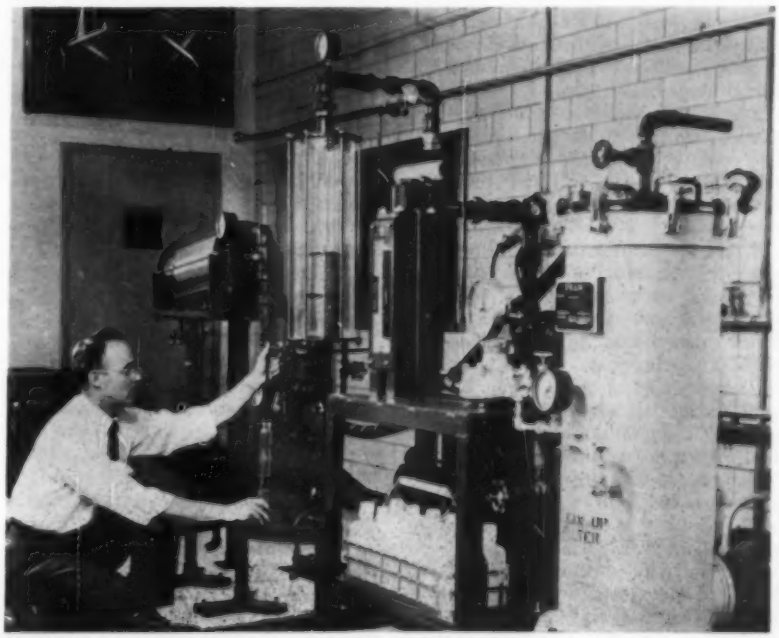
Until now there have been no size limits set for solid contaminants. Both civilian and military requirements have been based on the government specification for oil filters, Mil-F-8508A, which simply required the removal of a percentage of all contaminants. This specification is presently being rewritten and will probably include particle size limits based on the work now underway at Aeroshell Laboratory.

Shell's interest in the problem stems from its position as an aviation fuel supplier, selling more than 35% of the aviation fuel purchased for commercial use. Legally, its responsibility stops when it pumps the fuel into the air terminal storage tanks. Actually, when something goes wrong, Shell declares, the fuel companies are the first to get blamed by the airlines. While Shell has no interest in making fueling equipment, it feels that it is forced to set standards for this equipment to protect the interests of the company.

The problem of turbine fuel contamination is fast assuming major proportions. Now less than 100 million gal./year, the demand for aviation turbine fuel by U.S. airlines is expected to jump to about 1,300,000,000 gal./year by 1962. Moreover, there are many facets to the problem. Most important of these are the following:

- **Increased sensitivity** of turbine engines to moisture and foreign particles. Overseas, there have been instances where solid particles have blocked small passageways, resulting in the seizure of fuel pumps and stoppage of the engine. Less dangerous, but equally damaging and more common, are the cases where turbine fuel contamination causes premature failure of parts, requiring unscheduled repair and maintenance work. So far, engine sensitivity hasn't really been a problem in the U.S., says Shell, because The Rolls-Royce Dart engines which power almost all the turboprop aircraft here are relatively simple. But the introduction of the pure turbojets, the company declares, is going to change this.
- **Greater fuel consumption** of the turbine engines. Compared to the Douglas DC-7C which burns gasoline at the rate of 550 gal./hr., the Douglas DC-8 and Boeing 707-320 jet transports consume 2,300 gal./hr. of turbine fuel, while the smaller Boeing 707-120 burns about 1,800 gal./hr. This means that the chances for fuel contaminants to foul jet engines are three to four times as great as for piston engines.
- **Slower settling rate** of turbine fuels. Settling is an excellent method of lowering fuel contamination and is used, on the average, twice during the course of fuel transfer from supplier to aircraft—once in the storage tanks at the supplier's bulk depot and once in the storage tanks at the air terminal. At the same time, fuel handlers try to keep settling to a minimum; it takes time and ties up costly fuel. And, with the higher turnover of turbine fuel, settling could require additional storage tank installations which, according to one estimate, average $18,000 for a unit of two 15,000-gal. tanks. Standard settling time for aviation gasoline is 15 min. per foot of storage depth. For aviation kerosene, this will have to be lengthened to one hour/foot of depth to achieve comparable levels.

The solution to most of these problems, Shell believes, is the development of a filter separator which would remove all moisture and all solid contaminants above a certain size from turbine fuels without slowing down pumping operations or running into exorbitant costs. Each full scale evaluation of new filter-separators run at the Aeroshell Laboratory costs the company $5,000 to $10,000. But although no suitable filter has been developed—nor will Shell produce it when it is—the company considers the money well spent.



AEROSHELL engineer pumps contaminated fuel through filter set in lucite container.

Human Aspect Specialists Aid Designers

Los Angeles—Shrinking role of the human operator in man-machine defense systems now raises new and subtle problems of human engineering, hastening the growth of consultant firms capable of providing industry with specialized support in that field.

One of the largest, and perhaps most typical, human engineering consultant companies is Dunlap and Associates of Stamford, Conn., which has recently established an office here to be near West Coast missile and airplane manufacturers.

Human engineering specialists of Dunlap have taken part at some stage in development of virtually every current missile system as well as in conception of new aircraft and submarine control systems and in solution of many other problems.

Rapid growth of the company and others like it is more evidence that machinery is becoming too sophisticated to be designed by conventional engineering disciplines alone.

The growing importance of consultant specialists can be noted in other fields than human engineering. Nearly half of Dunlap's work is in systems analysis and operational research, a natural outgrowth of the emphasis in human engineering upon closed loop problems.

Growth Restriction

Missile and aircraft manufacturers tend to restrict growth of some specialist groups within their own engineering departments because deep knowledge of a highly specialized subject is seldom needed continuously. A consultant's fees end with his services, but it is impractical to lay off staff members when their usefulness is temporarily interrupted.

Chief contribution of the human engineering specialist to the job of design is use of more appropriate methods upon engineering problems dealing with human operations. Applied and experimental psychologists which make up the largest part of the Dunlap human engineering staff are experienced in laboratory and literature research and often find use for the capability. But in many contracts, specialized insight alone is adequate to spot the psychological booby traps that turn up in weapon system designs.

Dunlap holds a contract from U. S. Navy to integrate and monitor human factors aspects of work done by all subcontractors on the Lockheed Polaris missile. Some work is directly by Dunlap for companies which lack a human factors engineering staff.

A typical problem encountered on the Polaris was a conflict between the desire of Dunlap workers to seat the fire control officer at a console presenting all necessary information at one point and the Navy tradition that officers stand when on duty.

The Navy position is based on the argument that an officer is a supervisor and must be free to go quickly wherever he is needed. So the inevitable design compromise was made. All command information is presented at a single panel to comply with the Dunlap recommendation and it is chairless and centrally located to satisfy the Navy requirement.

Control Simplified

Jobs done by ballistic missile fire control teams in the operational countdown have been made as simple as possible because importance of each step makes operator errors intolerable. Since retaliatory weapons must react quickly, most work of preparing the ballistic missile for launch is done on a continuing or periodic basis so that it can be treated as a round of ammunition if war comes. The role of Dunlap and human engineering groups of various missile contractors is to cut the probability of operator error and lower reaction time by finding the best division of labor between man and machine, providing a coherent combination of data presentation and controls.

Ballistic missile launch control centers are commonly responsible for several missiles so that manpower and support equipment can be time-shared efficiently. The fire control officer at a land-based missile site or on a Polaris submarine has comparatively little to do in the countdown unless a malfunction occurs in one of the missiles or supporting systems.

He then must make a complicated decision on how to switch missiles from one target to another, how to re-assign time-shared supporting systems and how to alter the sequence in which the missiles are fired. This involves important calculations dealing with target priorities, time to be expended in launching all the missiles and time needed to correct different types of malfunction.

Dunlap now is studying ways of reducing these calculations to standard operating procedures. Difficult, unstandardized calculations raise too great a probability of error where target priorities are at stake. Possible reassignment of targets will have to be decided at high military and political levels and incorporated in standing orders of some sort. Creating standard procedures that will comply with these and consider every technical and tactical eventuality is not expected to be easy.

Critical Effect

Extremely critical effect of errors and lost time makes instrument and control layout important. Many functions in the countdown must be performed in sequence and if a step is missed, interlocks may open to prevent destruction of components. This would mean a new countdown with delays to the firing schedule.

In Polaris, Dunlap recommended installation of indicators and controls for the launcher console in a straight-line arrangement paralleling the sequence of events in the countdown. Some of the events are series of actions performed automatically by the equipment. When a light comes on to indicate the completion of the series, the operator pushes a button beneath it to start the next event.

Designers of missile launching complexes have tried to avoid making several missiles dependent on any single piece of support equipment. If it were not for manpower, cost and space limitations they would prefer to give each missile a complete individual support system. Since that is not possible, they duplicate most equipment and time-share it among the missiles. A schematic arrangement of failure indicators and system selector switches on the consoles gives the fire control officer the most readable presentation of his malfunction switching problem and his alternatives in the opinion of the human factors experts.

Semiautomatic ballistic missile check-out gear must also check itself where possible. The problem of determining whether a go-no-go light indicates the loss of component in the missile or in the check-out unit itself is a difficult and time consuming one for the human trouble-shooter. The fire control officer must know the answer to re-assign systems. To free the crew of this problem, Dunlap experts have advised that trouble indicators be linked to smallest replaceable module rather than systems of modules.

If a missile is shut down unnecessarily because of a fault that is really in check-

out unit, the countdown must be restarted at the beginning and involves considerable time spent in warm-up, gyro stabilization, etc. Designers are trying to reduce the frequency of check-out cycles during the long period of continuous peacetime maintenance because operation of components increases the liklihood of failure.

In some early missiles it was found that components with a life expectancy of 50 operating hours often underwent as much as 100 hr. of test in a relatively short time span. Experience indicates that a system is about as reliable 90 days after last check-out as it is after 30 days. Polaris support system also doubles as training device with a computer simulating the missile.

Guidance Systems

In Polaris, data is continuously drawn from the shipboard navigation system, processed and fed to the missile guidance systems. A feedback loop ensures that the missile is accepting the correct program. A discrepancy between input and output opens an interlock to prevent launch. The loop is loosely monitored by a crew member to make early corrective action possible.

Dunlap has tried to avoid the use of a human monitor where required to watch for a rare occurrence over a long period of time. He becomes easily distracted and unreliable. He is more effective if given some related actions to perform reasonably frequently. In some cases of this type it is better to let the man perform the operation with the machine acting as monitor.

As increasing performance and changing environment of weapon systems have raised problems beyond the ability of man to control directly, there has been a tendency to interpose nonhuman sensors, evaluating computers and semiautomatic control systems between him and his problem. This human engineering solution has raised new human engineering problems by narrowing the operator's role to that of decision-making, the least understood human activity. The progressive removal of the operator from the situation he is to control confronts the designer and his human engineering colleague with the task of supplying the operator an accurate and complete symbolic representation of the real world and a way of measuring the effect of his actions upon the tactical situation.

The task is an important one, for decision depends upon perception. Use of increasingly abstract symbols may lessen the operator's motivation, in the opinion of Dunlap's experts. Much of their work in the field of realistic symbolic display of information has been incorporated in the Douglas-Bell administered ANIP (Army-Navy Instrument Program) airplane and helicopter instrument panel development study. They have also been active in a similar program dealing with one-man control systems for submarines and surface vessels.

Navy officials have given a Dunlap study much credit for development of one-man airplane type controls used in the USS Albacore high speed experimental submarine and scheduled for use in Polaris-carrying subs. The technique was part of results attained in Project THERBLIG, a six-year time and motion study of general human engineering research on submarines and anti-submarine equipment. A motion picture study of 65 operator tasks on guppy submarines showed that in 64 there was some evidence of human error. The most serious of these were attributed mainly to inadequate equipment design, poor training and ambiguous operation procedures.

Project THERBLIG was asked to assist in design of Albacore controls because serious problem of depth control was expected to become worse due to the sub's high speeds. Its designers concluded that radically new controls would be needed to solve the problem.

Control of a conventional submarine requires three operators, a helmsman, bow planesman and stern planesman. Planesmen are responsible for controlling depth, rate of depth change, pitch and rate of pitch change. The operation calls for an unusual degree of teamwork which cannot always be maintained. At times, one planesman is given the job of correcting depth error and the other that of controlling pitch angle.

Either job is difficult, for displacement of a diving plane control does not cause a displacement of the plane but rather produces a rate of rotation. Therefore, position of the control tells the operator nothing about position of the plane. He must monitor the plane angle indicator to prevent any inadvertent maneuvers and must select a plane angle to give a rate of depth change proportional to the depth error.

The one-man control technique first employed in Albacore uses an airplane type yoke in which displacement of the control results in displacement of the rudder and planes rather than rates of displacement.

WHAT'S NEW

Telling the Market

Data, charts, and pictures of **Aer-Opak Thermocouples,** Bulletin 3.8A, Aero Research Instrument Co., 315 North Aberdeen St., Chicago 7, Ill. . . Details on blank sizes, thread sizes, dimensions and approximate shipping weights of **die cast cap nuts,** specification sheets, Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N. Y. . . . **Aircraft Service Equipment,** illustrated brochure, describes a new systems concept for the overhaul and servicing of jet engines, Automatic Warehouse Branch, Pesco Products Division, Borg-Warner Corp., Bedford, Ohio.

Riveting With Hi-Shears, booklet, gives installation and removal data for riveter and inspector, Hi-Shear Rivet Tool Co., P. O. Box 45545, Airport Station, Los Angeles 45, Calif. . . . Description of the line of **Color-Lite subminiature incandescent indicating lights** and accessories. Catalog A-58, the Sloan Co., 4101 Burbank Blvd., Burbank, Calif. . . . Engineering Catalog Sheet #50110-1A, gives essential data on **Rotron Propimax-2 fan** for cooling electronic gear in aircraft and missiles, Rotron Manufacturing Co., Inc., Schoonmaker Lane, Woodstock, N. Y.

Eccospheres, illustrated brochure on hollow glass microspheres for use as a dielectric material in molding compounds, radomes, heat barriers, etc., Emerson & Cuming, Inc., 869 Washington St., Canton, Mass. . . . Characteristics, specifications and illustrations of welded bellows for aviation, missile and instrumentation fields, Formweld technical brochure, Bridgeport Thermostat Division, Robertshaw-Fulton Controls Co., 155 Hill St., Milford, Conn.

Engineering Guide to Silocone Fluids for Mechanical Applications, Brochure 3-112, Dow Corning Corp., Midland, Mich. . . . Description, features and specifications on **Missile Test and Support Equipment,** George L. Nankervis Co., 15300 Fullerton Ave., Detroit 27, Mich. . . . **Leader on a New Frontier,** brochure, gives facts about facilities for aeronautical and astronautic products and missile hardware, Department FW-A17, The Firewel Co., Inc., 3685 Broadway, Buffalo 25, N. Y.

Illustrated booklet outlines structural static and dynamic testing, experimental stress analysis, hydraulic and pneumatic test, etc., of **missile components in the laboratory,** General Electric Co., Missile and Ordnance Systems Department, Room 5B, 3198 Chestnut St., Philadelphia 4, Pa. . . . New general catalog describes company's standard line of **quick-connect, quick-disconnect couplings,** Snap-Tite, Inc., Union City, Pa.

Operating principles, installation diagrams, dimensions and adjustment considerations of **Model 65 Vibraswitch Malfunction Detector,** Bulletin RF-586, Aeronautical and Instrument Division, Robertshaw-Fulton Controls Co., Euclid Ave. at Santa Ana Freeway, Anaheim, Calif.

Steel Honeycomb Brazed Continuously

By Craig Lewis

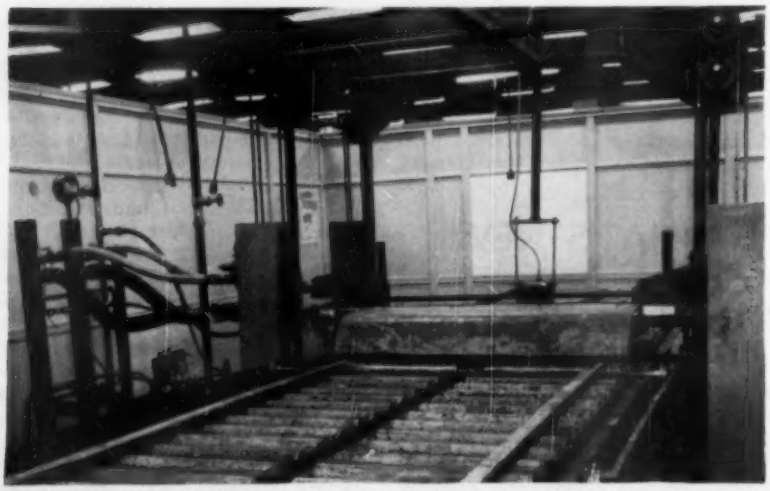
Dallas—An automated continuous process for brazing stainless steel honeycomb panels has been developed by Temco Aircraft Corp., and Temco engineers say it will do the job cheaper, quicker and better than present manufacturing techniques.

With this Temcombing process, panels are brazed as they move through a Temco-designed furnace at a regulated rate, then are stretch-formed to the desired curvature. The furnace and its feed system are flexible enough to handle panels of nearly any practical thickness, length or width.

Development of new processes for fabricating stainless steel honeycomb panels is significant in view of increasing speeds and temperatures encountered by aircraft of the North American Mach 3 B-70 and F-108 type and the corresponding need for materials to withstand these conditions. Temco has no production contracts for parts of such aircraft now, but says only that the new system was developed for future company prime or subcontract work.

The new process is designed to replace present batch techniques in which panels are made with carbon reference tooling and require several hours in a furnace to complete the brazing process. Temco system eliminates large furnaces, carbon tooling and the use of large quantities of inert gas, and the company contends that Temcombing is cheaper in both capital and operating cost. It is also faster than the carbon tooling method, and is expected to produce a better product because of fewer rejects, according to group engineer A. W. Graves.

STAINLESS STEEL honeycomb panel encased in its envelope and clamped in a chain-driven frame moves through the furnace area at Temco Aircraft Corp. Thermopile suspended over the middle rear of the furnace regulates panel speed to keep heating uniform. Line running from the panel envelope is used to maintain a partial vacuum of 3 psi. in the envelope's internal argon atmosphere. Pressure of evacuated envelope keeps parts together.



BURNERS which do brazing are under the hood of Temco's prototype furnace.

Prototype System

Prototype Temco system is designed around a strip furnace with two banks of radiant gas infrared burners. Furnace opening is 4 ft. wide and 15 in. deep. It is set in the middle of a table of rollers, and a chain drive along the side of the table is used to move the panel through the furnace, brazing it as it passes through.

To ready them for the process, panels, honeycomb core and brazing alloys are put together and covered with a common stainless steel envelope which is seam welded. The envelope is purged with argon, then evacuated, and a partial vacuum of 3 psi. is maintained throughout the process with the internal argon atmosphere. Pressure of the evacuated envelope has the effect of holding the panel components together.

Panel is clamped in a frame that moves it over the roller table and through the furnace. It moves at three to five inches a minute, and speed of the chain drive is controlled by a thermopile which sends signals to a temperature controlling recorder and controls a variable speed motor.

Speed is varied to maintain an even temperature on the panel and prevent warping.

Front burners preheat the panel to about 1,100F, then the second row of burners heats it to the brazing temperature of 1,750F. Preheating lessens

thermal shock and helps avoid distortion.

The brazing zone also puts the panel through the first stage of the heat treat cycle.

After brazing, the panel is cooled to room temperature and stretch-formed to the proper curved shape. This operation also removes any minor warping that may have developed in the brazing process. Temco applies tension to the panel on an ERCO stretch press, loading both faces evenly. A die is then brought up, draping the panel across its curve and forming the correct configuration.

Furnace system is in the development stage, and engineers are working on improvements. A change in instrumentation on the production version will add three more thermopiles, and these will be used to raise and lower the burners over the panel surface to maintain an even temperature. When this modification is perfected, panels will probably be run through the furnace at a constant speed.

Panel Width

Temcombing was developed to handle precipitation-hardened stainless steel, such as PH15-7M0 and 17-7PH, but it can also be used for titanium and other such metals. Panel width is now limited to four feet because that is the width of the furnace, but wider panels can easily be accommodated in a production version by widening the furnace. There is no limit to panel length except the practical limitations of the system used to feed the panel to the furnace.

Using induction heating, Temco has also developed a method for brazing fasteners to panels and for joining them to structure. For fastener provisions, panels are cut and a cup is inserted so that fasteners can be installed countersunk in the panel without crushing the honeycomb structure, using an internal wrenching bolt.

Machine Spins, Roll-Forges Metals

El Segundo, Calif.—Combined advantages of metal spinning and roll forging are achieved by a new machine designated Spin Forge. The 425,000-lb. tool costs $500,000 and will form metals up to 1-in. thick and 60 in. in diameter, while reducing wall thicknesses by up to one-half in a single operation.

The machine offers up new potential in the manufacture of large-size parts for advanced ramjet and rocket designs.

Designed and built by Hufford Corp., a division of the Siegler Corp., to Marquardt Aircraft Co. and Aircraft Industry Assn. specifications, the machine is financed by the Air Force's Air Materiel Command. Spin Forge will be used at Marquardt's Ogden, Utah, ramjet manufacturing plant.

Advantages of Spin Forge are:

- **Ability to produce shapes** of revolution such as cylinders, cones, venturis and parabolas, or combinations of these.
- **Reduction** of wall thickness in the forming operation.
- **Tolerances** of up to ±0.003 in. in wall thickness and diameter for pieces up to 60 in. in diameter.
- **Achievement** of machined-like surfaces on finished pieces.
- **Increases** in tensile strength of part, while decreasing ductility.
- **Formation** of shapes of revolution without weld seams.

Machine's Ability

During a demonstration, Spin Forge shaped a 60-in. disk of 321 stainless steel, 1-in. thick, into an outsized washbasin shape, while decreasing the metal wall thickness by one-half. Entire operation took 7¼ min. Particular shape was chosen to prove machine's ability as part of Hufford's demonstration to Marquardt.

It was emphasized by Hufford engineers that the metal was not being bent to shape over the mandrel, but was being formed by plastic deformation to the desired contour.

Spin Forge operates this way:

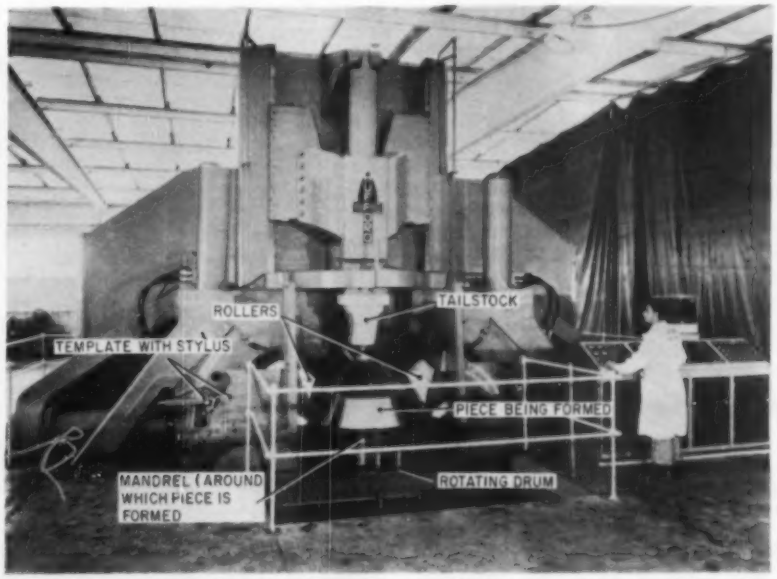
- **Rotating drum with mandrel affixed,** is moved out from machine hydraulically. Raw stock then is placed on the mandrel. This eliminates need for special handling techniques, since ordinary cranes can be used.
- **Tailstock presses** down on work with a force of 200,000 lb. Tailstock can also exert a pull of 100,000 lb. on work.
- **Drum rotates piece at** a speed which is infinitely variable from 10 to 400 rpm. The drum is driven by hydraulic motor and has a governing feature which will keep surface speed constant regardless of diameter variation.
- **Stylus traces on template** and sends information electronically to hydraulic actuators for the rollers. The rollers can exert up to 225,000 lb. in either a vertical or horizontal plane. Memory feedback information is returned to the stylus through this electro-hydraulic system and constantly corrects roller positions. This accounts for the close tolerances claimed for the finished product.

Electrical Heating

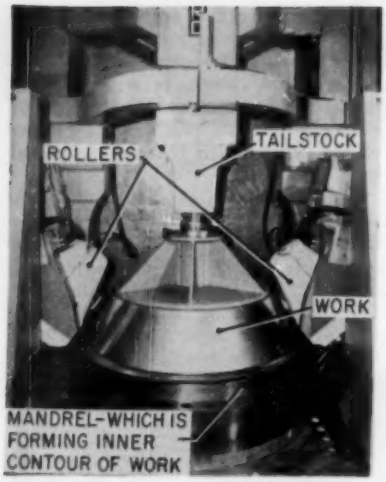
Electrical heating provisions are provided so that metals which cannot be cold-formed may be worked at elevated temperatures.

Provision is being made to install closed-circuit television cameras for viewing the work, so that the operator need not move from the control panel. This also protects personnel if the piece being worked has an undetected flaw. Due to extreme pressure, flaws in materials can cause explosive disintegration.

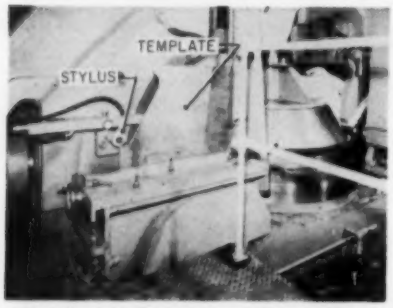
Tailstock pressure is released, drum



SPIN FORGE weighs 425,000 lb., is shown during a roll forming operation using 321 stainless steel. Mandrel is a die around which the stock is formed. Finished product is about half its original thickness and has machined-like surfaces.



FINISHED piece shows machined-like surface. Rollers, capable of nearly million lb. of force, are on either side. Piece is composed of stainless steel.



STYLUS tracing template; position of stylus is transmitted by electrohydraulic means to the rollers.

and mandrel are moved out from the machine, and a crane picks up the finished part.

One of the most difficult engineering problems in the development of the machine was the design of the hydraulic actuators for the rollers. Hufford originally sought help from manufacturers of hydraulic valves. No one seemed willing to tackle the problem of designing valves to handle the 225,000 lb. actuator pressure and a 3,000-psi. system.

Hufford solved the problem by designing variable volume pumps and eliminating the need for valves.

Metals Experiments

Experimentation in the working of various metals is still going on at Marquardt, including the investigation of what can be done with "exotic" metals.

As an example of what the Spin Forge will do, a conventional (1100) aluminum alloy, in a 65% reduction, emerged with an increase of 600% in yield strength while tensile elongation decreased from 35 to 5%.

Titanium also can be processed on Spin Forge, according to Marquardt. Commercially pure (70,000-psi. yield strength) and 5.1A1-2.5Sn (Allo-AT) titanium alloys were investigated, and while all tests were conducted at elevated temperatures (800-1,400F), indications are that the commercially pure titanium may be worked at room temperature. While no increase in tensile or yield strength is gained in Spin-Forging titanium, neither is there a loss.

Presently, Hufford is disassembling the Spin Forge for shipment and erection at Marquardt in Ogden. Further tests to determine the machine's capabilities in newer ramjet and rocket applications will be conducted. Dovetailing with this and future production schedules, Marquardt will handle other manufacturers' requirements which may demand the use of the government-owned Spin Forge.

One other machine already is under construction for Hufford's own use while construction of a third machine will be started shortly for General Electric Co.

Continuous-Path Machine Tool Movements Prerecorded on Tape

Inglewood, Calif.—Micro-Path, a simplified system for machine tool control that utilizes magnetic tape to store a prerecorded program, was demonstrated here by Micro-Path, Inc., a subsidiary to Topp Industries.

System costs between $15,000 and $25,000. Machines may be purchased in several combinations since units are offered in modular form.

Recording Tape

Micro-Path provides a means of recording continuous-path machine tool movements on tape without use of the usual computer programing equipment.

Basic system can be applied to existing machine tools or can be designed into new machines.

Recording and playback controls are located on top control panel of console. Advantages claimed for Micro-Path system include:

- **Three-axis** motion control necessary for continuous path work, such as profile and contour milling as well as point-to-point operations such as drilling.
- **Greater speeds** than manual production methods.
- **Accurate locating** within .001 in. with fail-safe checks preceding each cutting operation to ensure accuracy of table position relative to program.
- **Fully loaded cutters** operating at maximum efficiency on every cut.
- **Rapid traverse** between cuts with correct feed rates on cutting operations without loss of time between operations.
- **Accurate duplication** of parts without jigs or locating fixtures.
- **Reduced scrap** and inspection time and material cost.
- **Reduced programing** time.
- **Elimination** of specially trained operators.

DIES are produced with Micro-Path contour table and bank of eight vertical drilling heads.

General Electric J85 Variations

Three models of the General Electric J85 lightweight turbojet engine each have a different application. J85-1 in foreground is prototype engine for Northrop T-38 supersonic jet trainer. Just behind it is J85-3, powerplant for McDonnell GAM-72 decoy missile, and at right is J85-X, which powers the prototype North American T-39 Sabreliner.

PRODUCTION BRIEFING

Topp Industries, Inc. of Los Angeles, has announced formation of U. S. Science Corp. New company, a wholly-owned subsidiary, will acquire operations of Topp Manufacturing Co., a division of Topp Industries.

Switzer Brothers, Inc., Cleveland, Ohio, will furnish the Navy with 30,000 gal. of Day-Glo fire orange aircraft paint. Included in the 30,000 gal. is a clear overcoat which resists the fading effects of the sun. High visibility paint is intended to aid in the prevention of midair collisions.

Cleveland Aero-Space Assn., a group formed to bring major missile contracts to the Cleveland, Ohio area, has appointed Glenn G. Anderson as group administrator. Anderson, employed by the Cleveland Electric Illuminating Co., will be "on loan" to the newly formed organization to guide its initial operations.

Standard Railway Equipment Mfg. Co., Chicago, Ill. will produce 1,280 ft. of steel blast fencing for installation at Eglin AFB, Fla. Blast fence, to be placed at runway ends in 80 to 100 ft. lengths, will be solid sheet steel, 10 ft. high.

SKF Industries, Inc., Philadelphia, Pa., has acquired Reed Instrument Bearing Co., Los Angeles, Calif. Reed, operating as a division of SKF, will bring the bearing corporation into the aircraft instrumentation and missile bearing field.

Telecomputing Corp., Los Angeles, Calif., will build motor-operated butterfly shut-off valves for Pratt & Whitney engines under $501,116 contract. Valves, produced by the corporation's Whittaker Controls Division, are used in the anti-icing system of the J57 turbojet engine.

Follow-on contracts for component production on Boeing B-52G missile platform bomber have been awarded to Temco Aircraft Corp. ($7 million) and Goodyear Aircraft Corp. ($2 million). Temco will continue construction of 58-ft. aft fuselage sections; Goodyear is building center wing sections and top panels at its Litchfield, Ariz., plant.

Eclipse-Pioneer Division of Bendix Aviation Corp. will start production of air data computers for McDonnell F-101 and Republic F-105 fighters this spring, on the basis of a $9,446,417 contract awarded by U. S. Air Force. Similar computers have been ordered for Convair F-106 and Convair B-58.

Royal Netherlands Air Force has ordered six Sud Aviation Alouette helicopters. Delivery of the turbine-powered aircraft will be completed in summer.

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CAB Accident Investigation Report:

PanAm Crash Cause Remains 'Unknown'

Pan American Flight 7, a Boeing 377, N 90944, was lost in the Pacific Ocean approximately midway between San Francisco, Calif., and Honolulu, Territory of Hawaii, on Nov. 9, 1957, at 1627 local time. An extensive sea and air search over thousands of square miles of ocean ensued. Bodies of 19 of the 44 occupants were found as were small and light aircraft parts and cargo.

HISTORY OF THE FLIGHT

Clipper 944,[1] a regularly scheduled around-the-world flight, originated at San Francisco with its first stop scheduled at Honolulu. It departed San Francisco at 1951[2] on Nov. 8 estimating arrival at Honolulu at 0550, Nov. 9. There were 36 passengers and a crew consisting of Capt. Gordon H. Brown, First Officer William P. Wygant, Second Officer William H. Fortenberry, Flight Engineer Albert F. Pinataro, Purser Oliver E. Crosthwaite, Stewardesses Yvonne L. Alexander and Marie L. McGrath, and Flight Service Supervisor John E. King.

The flight plan specified a cruising altitude of 10,000 ft. and a true airspeed of 226 kt. Gross weight at departure was 147,000 lb., the maximum allowable, and the weight included fuel for approximately 13 hr. Good weather was forecast for the duration of the flight.

All required position reports were made and Clipper 944 reported to Ocean Station vessel "November" at 0030; its position was fixed by radar as 10 mi. east of the vessel. The last position report, at 0104, was routine with no indication of anything unusual.

The next scheduled position report, due at 0204, was not received and 30 min. thereafter the flight was designated unreported.

INVESTIGATION

Search and Rescue operations were initiated immediately. Coast Guard surface vessels, air carrier aircraft, Air Force aircraft, and the U.S. Navy aircraft carrier "Philippine Sea," using its aircraft, participated.

On Nov. 14, the fifth day of search, aircraft from the carrier located bodies and parts of wreckage some 940 mi. east of Honolulu and approximately 90 mi. north of the flight's intended track. The next day additional bodies were recovered making a total of nineteen. Fourteen of these wore lifejackets. Bodies and material were taken aboard the carrier. Continuing intense search was unproductive and was abandoned on the evening of Nov. 15.

Meanwhile, investigating groups had been formed under the direction of the Civil Aeronautics Board. Two Board investigators, representatives of Pan American World Airways and the CAA, and two pathologists of the Armed Forces Institute of Pathology on loan to the Board, were flown to the carrier, then at sea en route to Long Beach, Calif. This permitted initiation of the investigation a full day before the carrier docked. The wreckage was briefly examined by the medical members and investigators with the prospect of gaining some insight of possible medical problems that might be encountered.

External examination of the bodies was made, carefully noting all external injuries. There was no evidence of foul play found on any of the recovered bodies. Tentative identification was established in those cases where possible. All valuable personal items were inventoried and preserved under the supervision of one of the ship's chaplains.

Preliminary examination of the limited amount of material aboard the aircraft carrier established that it was from N 90944. All wreckage was removed to a restricted area at the Pan American overhaul base at San Francisco where further examination was made by Board investigators. Various pieces were identified individually and relative to one another and a detailed examination of the pieces was made.

Recovered Material

The recovered material consisted chiefly of fuselage secondary structure, fuselage interior trim and equipment items, and numerous separate packets of mail and mail bags. Only one piece of wreckage from parts of the aircraft other than the fuselage was recovered; this was a section of engine cowl support ring, which was found imbedded in a floating pillow. It could not be determined from which powerplant this piece of ring came. No portions of the main airframe structure were found. The recovered fuselage pieces were generally from the areas ahead of the rear pressure bulkhead. The pieces were from both above and below the cabin floorline, and a somewhat greater amount of the material had come from the right side of the fuselage.

Some of the recovered pieces bore distinct evidence of fire damage. However, it was determined that the fire damage on all pieces was on those portions which floated above the water. No evidence of inflight fire was found on any of the recovered fuselage material. Fire markings were fairly uniform over material from all positions in the fuselage, including mail and cabin material, and each charred piece had a definite waterline below which charring did not occur. Laboratory tests of the charred pieces disclosed no evidence of prohibited or explosive material.

Board investigators carefully examined the recovered debris for evidence of an inflight explosion. This examination included a thorough inspection of recovered items of cargo, passenger effects, and mail. No evidence of an inflight explosion in the fuselage was found.

Cargo manifests were examined to determine whether any explosive or otherwise dangerous material was aboard. A shipment of sodium sulfide had been in the forward cargo compartment. A check with the shipper disclosed that the packaging consisted of one pound in a sealed glass container and one-fourth pound also in a sealed glass container padded from each other and the shipping container, which was a wooden box 13 in. by 11 in. by 9 in. It was further learned from the shipper that the material consisted of crystalline sodium sulfide of the highest ACS (American Chemical Society) grade of purity and was the only chemical compound shipped in the box. It had been packaged in accordance with prescribed regulations.

Sulfide Handling

Sodium sulfide is a chemically reactive flammable solid. It is normally shipped in airtight containers in a yellow crystalline form which even if exposed to air would be safe to handle and to transport. Crystalline sodium sulfide in contact with moisture would generate hydrogen sulfide gas, which is toxic, at a slow detectable rate. The amount of hydrogen sulfide generated would not be great or dangerous before its very foul and characteristic odor of rotten eggs would alert the crew to take emergency procedures—i.e., use a smoke mask, and depressurize the aircraft and ventilate. This material is rather widely used industrially and its shipment by air is not uncommon.

Also included in the cargo was a package containing a small amount of radioactive medicine which had also been packaged in accordance with prescribed regulations. It was reported to have been sealed in a Babbitt metal capsule about one inch long contained in a hermetically sealed can. This can was then placed in a cardboard carton which was identified by a label indicating radioactive material.

Neither of these two shipments was recovered but there is no reason to suspect that either one contributed to the accident. The remainder of the cargo consisted of routine mail, baggage, and express shipments which included several barrels of tranquilizer and several shipments of movie film of the "Safety" type.

N 90944 was equipped with two complete high frequency radio transmitting and receiving systems. The two systems were also equipped with SELCAL which provides ground-to-air selected calling, eliminating the need for continuous pilot monitoring of the high frequency communication equipment of the aircraft. The ground equipment generates pre-set coded tones which are transmitted on voice communication frequency.

On receipt of the particular tone code the aircraft decoder activates the cockpit call chime and signal light. This SELCAL phone is on the control pedestal

[1]Company designation of Flight 7, using the last three numerals of the aircraft number.
[2]All times and dates herein are Greenwich unless otherwise noted and are based on the 24-hr. clock; all distances are in naut. mi.

between the pilots, readily usable by both.

In addition to SELCAL, the conventional equipment was available to the crew by activating a toggle switch for either system. In either system it is necessary to depress the microphone button to transmit. Additionally, the aircraft had two separate very high frequency systems and two automatic direction finding receivers providing aural reception and radio bearings from the stations in the low frequency and broadcast band.

Air-to-surface and surface-to-air communications on very high frequency during takeoff and immediately following departure of Clipper 944 on Nov. 8 were routine and normal. These included clearances with the San Francisco tower, radar departure control, and CAA Air Route Traffic Control Center. Upon reaching cruising altitude (10,000 ft.) at 2009, Clipper 944 switched over to company frequency and contacted ARINC (Aeronautical Radio, Inc.), which handles all company surface-to-air communications for Pan American. A schedule was established for position reports from the flight at four minutes past each hour and an "operations normal" report at 34 min. past each hour.

Position Report

At 2105 Clipper 944 made its first routine position report, which indicated the flight was proceeding as scheduled. Thereafter, Clipper 944 continued to report its progress as scheduled at four and 34 min. past the hour through its last position report of 29 deg., 20 min. north and 141 deg., 35 min. west at 0104. Prior to this position report Clipper 944 established radio communication at 0030 with Ocean Station "November" and two radar fixes were obtained by that vessel which fixed the position of the aircraft as bearing 243 deg. true range 43 mi. from the vessel at 0040, approximately 10 min. ahead of schedule. At that time Ocean Station "November" was 29 deg., 59 min. north and 140 deg., 8 min. west. With this information it is probable that Clipper 944's navigator estimated his position, at 0104, as an average between his own estimate of his position and the correction indicated by the radar fixes.

The Board considered it entirely possible that an emergency message might have been sent from the flight after the 0104 position report and that such message might not have been heard. Pursuing this possibility the ARINC recording tapes for the frequency in which such message would be recorded were carefully examined. Initially nothing was apparent. However, repeated playbacks of the tapes of the period following the 0104 position report disclosed previously unknown transmissions which were extremely weak and subject to varied and conflicting interpretation.

Great effort was devoted to determining the content, or the intent, of this transmission.

Altogether, more than three months were devoted to this work, using various proven and experimental methods as well as the finest equipment.

Another attempt to understand the message was made by Pan American World Airways. A number of its supervisory flight and communications personnel, accustomed to the abbreviated jargon of air radio communications as well as having had personal experience in previously talking with the crew members, were unable to gain any significant intelligence from repeated playbacks of the recorded message. Despite this comprehensive research, the Board could not definitely establish that any emergency transmissions came from Clipper 944.

Board investigators obtained the identification of 44 other flights which were operating through the area of the last reported position of Clipper 944 during the period 2400 to 0200 on Nov. 8-9. None of the crews of these flights had overheard any calls from Clipper 944 during this period on company or any other frequencies, nor did Ocean Station "November" hear any emergency message from Clipper 944 following its last position report at 0104. (All PAWA aircraft as well as those of certain other carriers, namely, Northwest Airlines and United Air Lines, transmit and receive on common frequencies.)

When Clipper 944 failed to report at 0134 and again at 0204, the next routine reporting scheduled, both Honolulu, which then had flight guard responsibility, and San Francisco attempted to contact the flight on all frequencies. All subsequent attempts to contact the flight were futile and Search and Rescue was alerted at 0234; search was started immediately. Bodies and debris located by aircraft of the U.S.S. Philippine Sea were at 29 deg., 36 min. north, 144 deg., 3 min. west. The probable point of impact was near 29 deg., 26 min. north, and 143 deg., 34 min. west. The position was computed from known ocean current vectors published by the Hydrographic Office, taking cognizance of reported winds. The position of Lat. 29 deg., 26 min. north, and Long. 143 deg., 34 min. west, is approximately 105 mi. west of the last reported position and about 30 deg. off course to the right (north).

On the basis of surface ship reports (including Ocean Station vessel "November") and aircraft weather reports, it is apparent that the weather en route was substantially as forecast. Clouds consisted of scattered to broken cumulus and stratocumulus based at 2,000 to 3,000 ft., tops 5,000 to 8,000 ft., with scattered to broken clouds above 12,000 ft. The over-all wind pattern coincided closely with the forecast. There were no reports of turbulence, icing, lightning, thunderstorm activity, or precipitation of any kind.

The forecast lowest sea level pressure in the accident zone (from 140 deg. to 145 deg. west) was 1018 mbs.; actual values ranged from 1020-1023 mbs.

The winds reported at Ocean Station "November" (averaging the 0000Z and 0600Z observations) were as follows: 2,000 ft.-250 deg. at 8 kt.; 6,000 ft.-270 deg. at 8 kt.; 10,000 ft.-250 deg. at 12 kt.

The visibility at Ocean Station "November" at 0000Z and 0300Z was reported as 10 naut. mi. while the cloud conditions were as follows:

0000Z — less than 1/10 cumulus based at 2,000 ft.
2/10 stratocumulus based at 4,500 ft.
3/10 cirrus at an unspecified height (but well above flight altitude).

0300Z — 1/10 cumulus based at 2,000 ft.
7/10 cirrus at an unspecified height (but well above flight altitude).

Ocean Station vessel "November" also reported the following with respect to the state of the sea at 0000Z, Nov. 9:

(a) waves coming from 300 deg.
(b) period of waves: 11-13 sec.
(c) mean maximum height of waves: 8 ft.

The air temperature at 10,000 ft. in the area of the crash was approximately plus 4 deg. Centigrade.

Because of the limited amount of wreckage recovered, it became all the more important to determine as much information as possible from the recovered bodies in order to arrive at a better understanding of the emergency that had caused the accident. It was chiefly for this reason that the Board enlisted the aid of expert pathologists familiar with aircraft accident fatalities to assist in the development of all significant information. Their examination of the 19 bodies recovered disclosed that 10 had prob-

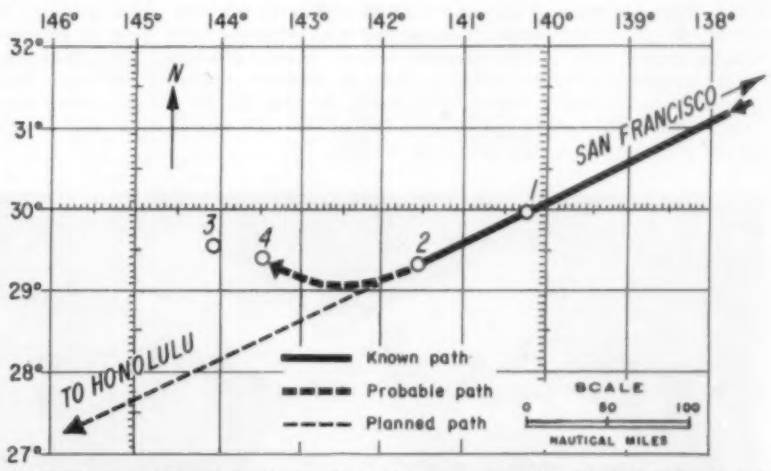


CHART shows position of weather vessel (1); last reported position of Boeing 377 (2); area where bodies and wreckage were found (3) and probable impact point (4).

ably died from drowning. Further, the lack of extensive crash-induced mutilation, together with the general condition of the bodies, suggested that the water impact, although severe, was not sufficiently great to cause complete disintegration of the aircraft.

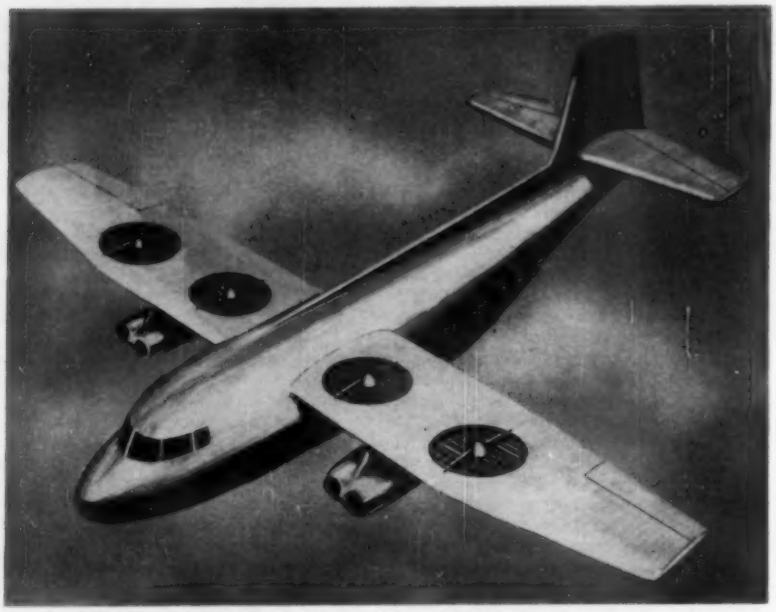
Life preservers were found on 14 bodies, two of them children. One of the recovered bodies, wearing a life preserver, was one of the stewardesses who was still strapped by her safety belt to a seat.

Bruises and abrasions on the thighs of the captain's and the purser's bodies indicated that their seat belts also were fastened at the time of impact. Similar indications were lacking on other bodies. The medical examination further disclosed that none of the bodies had been subjected to fire before or after impact.

As part of the pathological examination, a series of tests for toxic material was conducted. Initially these tests indicated elevated levels of carbon monoxide in several of the recovered bodies. This preliminary finding indicated (1) the need for further corroborating tests, and (2) that a study should be undertaken to determine how high concentrations of carbon monoxide could have been present in the inhabited portions of the fuselage. To accomplish the latter objective a Board investigating group made a detailed study of the Boeing 377 systems to determine possible malfunctions which could lead to the generation of carbon monoxide. These were considered with probable variations in the pattern of airflow throughout the fuselage.

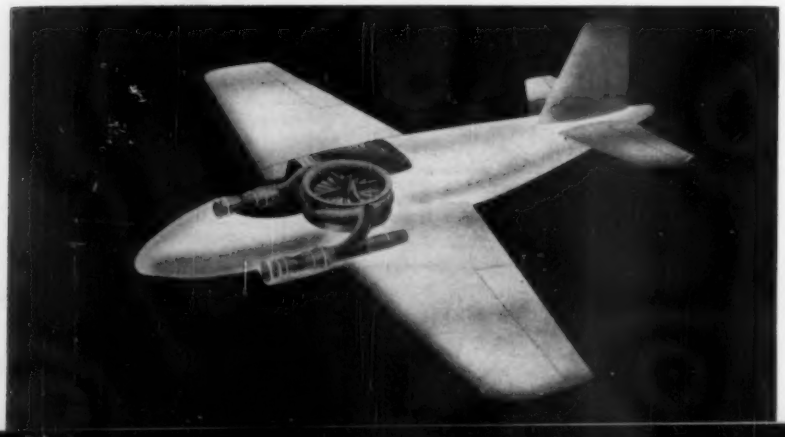
This study disclosed that high levels of carbon monoxide could be generated and distributed unevenly throughout the fuselage in several ways. However, it was impossible to relate the elevation of carbon monoxide found in bodies with the seating arrangement and, consequently, with the source of the carbon monoxide.

Medical tests have continued from the time of the accident to the present to verify the initial findings relative to carbon monoxide concentrations in certain of the bodies. These tests, conducted independently by different federal agencies, verified the concentrations as found initially but raised doubt as to the suitability of any test method because of the decomposed state of the bodies. Additional studies are presently being performed which may answer the question regarding reliability of carbon monoxide results in cases of post-mortem decomposition, but as yet this question is unsolved.



Convertible Jets for VTOL Aircraft

Use of convertible turbine engines to efficiently provide sufficient power for vertical takeoff and economical, low-weight propulsion for forward cruise flight is being studied by General Electric's Flight Propulsion Laboratory Department, Cincinnati, Ohio. Proposals shown, using General Electric J85 turbines, would duct hot gas to a turbine driving one or more lifting fans for vertical takeoff and landing; for level flight, the system would be converted to provide conventional turbojet power. Valves in the duct and engine tailpipe would control gas flow. General Electric design study (top) envisages a four-engine 30,000-lb. VTOL transport capable of carrying a 4,000-lb. payload for 600 naut. mi. at speeds up to 320 kt. By interconnecting gas generators and fans, engine-out safety could be provided, General Electric notes. Another proposal (bottom) depicts a twin-engine Army observation aircraft weighing 13,500 lb. including 600-lb. of electronic equipment. Maximum flight speed at sea level could be 550 kt., cruise radius 200 naut. mi. with two-hour loiter time. Without loiter time cruise range would be 700 mi. Two J85 engines would drive a single lift fan buried in the fuselage behind the cockpit.



Watches Recovered

Five recovered wrist watches were examined by a competent watch maker to establish an approximate time of impact. Of these, two had been stopped by impact at 26 and 27 min. past the hour, respectively. Two were automatic winding, shockproof and waterproof, and one of these was still running, showing the correct time when recovered. The other was full of water and had stopped at 35 min. past the hour. Since the "waterproof" case was intact and showed no physical damage, it was concluded that it ran for some time before being stopped by water seeping in. The remaining watch, which had a nonwaterproof case, had stopped at 28 min. past the hour and had water inside. This was considered to be the probable cause of stoppage. Considering the waterproof integrity of the case of the watch showing 35 min. past the hour and eliminating the one still running, a probable time impact was established as 27 min. past the hour. Since the aircraft had reported at 0104 and did not report, as scheduled, at 0134, the time of the crash is concluded to have been 0127.

An inspection was made of all company maintenance records of N 90944. This included records of the aircraft structure, powerplants, and all accessories. A detailed study of these records, which were adequate and in good order, showed that all airworthiness directives had been complied with and that no known discrepancies existed at the time the aircraft was dispatched on this flight. The aircraft, a Boeing 377, was manufactured by the Boeing Airplane Co. on Aug. 19, 1949. Pan American acquired it on Sept. 28, 1950, and it had been operated in air carrier service since that date. It had been progressively maintained and was currently certificated.[3]

[3]Progressive maintenance is a system whereby overhauls of aircraft are divided into segments so that complete overhaul is not required at one time.

The aircraft was equipped with four Pratt & Whitney model 4360B-6 engines.

Propellers installed on these engines were Hamilton Standard model No. 34E60-349, blade model 7015B-2. The propeller domes had incorporated the recently developed speed sensitive pitch lock to minimize uncontrolled engine overspeeds. The blades were solid aluminum. All blades and hubs of each propeller had been overhauled and maintained as complete units since new. Records of the carrier's fleet of Boeing 377's in the Pacific-Alaska Division were examined and revealed that no propeller structural failures had occurred since the adoption of this model propeller.[4] None of the propellers on this particular aircraft had been involved in any overspeeding incident. Each engine was equipped with a General Electric model CH10 turbosupercharger. These provided pressurized air for the cabin air conditioning system as well as air for engine supercharging.

Loud Noise

On Sept. 19, 1957, when N 90944 was on a trip from Honolulu to San Francisco, the crew heard a loud noise. It was described as similar to dropping the navigation stool on the flight deck. The captain made a check of the lower nose CO_2 bottles and the forward cargo compartment, accessible through a floor hatch in the cockpit. The antennas were checked through the octant and everything was found normal. This incident was written up on the flight engineer's log (Discrepancy Report) and, in addition, suspecting a tire blowout, a tire check was requested by the captain prior to landing at San Francisco. This was accomplished by extending the gear and requesting a visual check by tower personnel. No tire damage was observed and a normal landing was made.

Since this incident was written up as a discrepancy, it required an inspection which was signed off with the following action by a company inspector, "Inspected aircraft and found no damage outside." Inasmuch as this indicated no interior inspection of the aircraft, Board investigators further questioned the company inspector who signed off the discrepancy. His statement of action taken follows: "Inspected lower nose and forward cargo compartment, also exterior of aircraft. Found you could duplicate loud noise by stepping hard on door between cockpit and cargo. Also loud bang could be duplicated by dropping forward toilet lid. Nothing abnormal found."

Two "hard" landings had been reported by crews on June 4, 1957, and Oct. 3, 1957, respectively. Following the first, inspection of the aircraft (N 90944) by certificated mechanics included a visual inspection of all outer skins for wrinkles, fuel stains in cell areas, cracks or damage to landing gear, lowering of flaps and inspection of flap area and landing flaps themselves. No visible damage was found. One item in the inspection required in the manual, namely, removal of a surface cover for inspection of the wing spar webs, was omitted; however, the mechanics who performed the inspection were satisfied that there was no damage to the aircraft and accordingly "signed off" the inspection form. The second hard landing was followed by an inspection which was reported verbally by the inspecting mechanic, to the captain of the flight, as complete. This verbal report was accepted by the captain since in his opinion the landing was not sufficiently hard to warrant a written report.

N 90944 had made 41 flights during the period Sept. 19 to Nov. 8, 1957, the date of Clipper 944's departure from San Francisco. The pilots on these flights were questioned regarding any unusual noises, turbulence encountered in flight, hard landing, or any other significant occurrences, which were not made a matter of record. Nothing was reported that shed any light on the accident.

Final Inspection

The last preflight inspection was started on Nov. 6, 1957, and continued until the date of departure, Nov. 8, 1957. All items required had been checked and signed off by appropriate maintenance personnel.

During the course of the investigation, and in view of the circumstances of the disappearance of the aircraft and the absence of living witnesses or crew members, an extensive investigation of personal activities and backgrounds of crew, passengers, and company ground personnel of the San Francisco base of PAWA was made by CAB and other governmental agency personnel.

This investigation included personal interviews with all personnel who might have had access to the aircraft for any reason while the aircraft was on the ground on its last stopover at San Francisco from Nov. 6, 1957, to Nov. 8, 1957, and involved some 98 persons. This phase of the investigation disclosed that the aircraft received normal preparation for the flight and disclosed nothing relative to the character or behavior of any person that might point to sabotage in connection with the loss of the aircraft.

Specific Maintenance

Subsequent to the public hearing, the Board conducted an investigation of specific maintenance and overhaul practices and occurrences at the carrier's San Francisco base. The purpose of this investigation was to obtain information by which maintenance adequacy of the carrier's Boeing 377 aircraft and powerplants could be evaluated; consequently, a part of the investigation related directly to these aircraft.

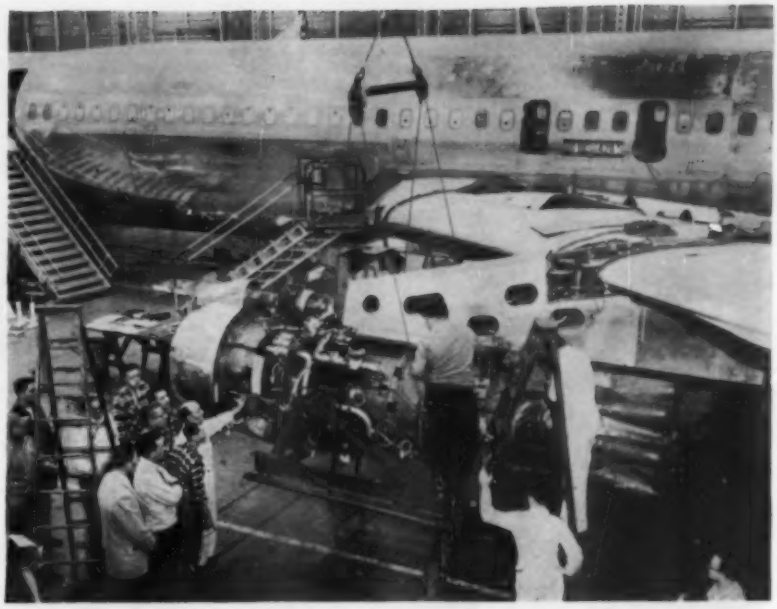
A number of irregularities in maintenance procedures and/or practices were noted. However, because the airplane was lost at sea with no message giving any clue as to the nature of the emergency and because there was no direct application of these irregularities to 944, it is obviously impossible to associate them with, or disassociate them from, the accident.

The subjects of emergency procedures, and crew training and competency therein, were investigated. It was established that the company's emergency training curricula, including ditching, fire fighting and smoke evacuation procedures, were adequate and that all crew members of N 90944 had successfully completed the required training.

It is obvious from the investigation portion of this report that an analysis to arrive at the probable cause of the accident is seriously handicapped by the scarcity of physical evidence. However, the following seems logical.

If a large-scale fire had occurred in the cabin, cockpit, baggage compartment, or

[4]However, military services have experienced engine nose section difficulties attributed to the use of the solid aluminum propeller which is considerably heavier than the model previously used.



Rolls-Royce Conway Mounted on 707-420

First Rolls-Royce Conway turbojet engine, rated at 17,000 lb. thrust, is mounted on Boeing 707-420 Intercontinental transport being built for British Overseas Airways Corp. The 707-420 is the first of 15 Intercontinentals ordered by BOAC. Conway engines also will be used on 707-420s ordered by Lufthansa, Varig Airlines and Air-India International U.

San Francisco International Airport Design Proposal

Architect's drawing of proposed development of San Francisco International Airport terminal facilities envisions two new terminals (Y-shaped structures); new piers connecting concourses and three-level parking structure. Design is by Welton Beckett & Associates.

lounge area, some evidence of such fire would most probably be present in the recovered pieces. Since none was found, it is reasonable to conclude that a large-scale fire did not occur in any of these areas. There was no physical evidence to indicate the occurrence of a powerplant or localized fuselage fire nor was there any evidence to indicate that there was no such fire. Although a powerplant or localized fuselage fire would not immediately destroy the structural integrity of the aircraft, both the indicated lack of directional control and absence of any distress message could well be associated with this kind of emergency.

Fire Damage

Such fire could generate considerable quantities of smoke which might present serious difficulties to the crew. However, equipment is provided to combat such an emergency and the crew is trained in its use. Fire damage that was observed on the floating debris was confined to those surfaces which were above the waterline. Obviously, this damage could have been caused only by a surface fire following impact.

Clipper 944 made five routine hourly position reports after its departure from San Francisco, the last one 21 min. prior to impact with the water. After the last routine position transmission, the aircraft descended from 10,000 ft. going away from Ocean Station "November" which it had passed some 35 min. before.

As has been stated, the location of impact was computed to be in the vicinity of latitude 29 deg., 26 min. north and longitude 143 deg., 34 min. west. This is approximately 105 mi. west of the last position established for the aircraft and about 30 deg. off course to the right or north. Lack of knowledge of both the time and start of descent and precise impact point makes it impossible to determine by analytical means, or otherwise, the airspeed or the descent rate existing during the descent.

A fairly flat angle of impact is indicated by the nature of damage to the recovered material, its location within the aircraft, and by the lack of severe mutilation of bodies. The part of the aircraft from which the recovered wreckage came indicated breakage of the fuselage at about the same locations as has occurred on previous survivable ditchings of the same model aircraft. These circumstances suggest a nearly survivable ditching may have been accomplished. From this it would logically follow that some control may have been available at the time of water impact.

Exercise of such control would tend to rule out crew incapacitation.

However, two pertinent conclusions regarding the final portion of the flight are evident. Consideration of the distance flown from the last reported position to the impact point, and of the time required to traverse that distance shows that the flight did not turn back toward Ocean Station "November." Also, the ditching to the north of the planned route indicates that appreciable lateral distance, not on course and away from the ocean station, was traversed after the start of the emergency.

It is difficult to understand why the captain would have elected to continue away from "November" had he been able to do otherwise. Weather was not a factor and it is not believed that the shipping lanes to the north offered any inducement to turn in that direction. Conversely "November," a fixed ocean station equipped with radio homing and radar devices and rescue equipment, was in close proximity with trained personnel readily available.

The condition of the sea at the time and place of the ditching is not known precisely, but it should not have been appreciably different from that existing at the weather vessel 105 mi. to the east. That vessel's official observation at 0000, one hour and 27 min. before the ditching, included: waves from 300 deg. at a frequency of 11-13 sec. with a mean maximum height a 8 ft. Surface winds were southwest 11 kt. These conditions would produce a usable sea surface for ditching. One airline captain en route near the place and close to the time of the ditching stated that seldom had he seen the sea conditions more favorable for ditching. Due consideration of all these factors leads to the belief that either loss of directional control or crew incapacitation was the possible cause of the aircraft proceeding away from "November" after the start of the emergency.

Previous Emergencies

There is a record of previous emergencies involving Boeing 377 aircraft which were accompanied by serious directional control difficulties. Emergencies referred to, except one, followed complete separation of a powerplant from the aircraft. The one exception occurred following takeoff with the cowl flaps fully open. Common to all of these occurrences was heavy buffeting in flight and in the case of powerplant separation, great difficulty in simultaneously maintaining altitude and directional control. Such occurrences bear a striking resemblance to what appears very likely to have occurred to 944.

Buffeting, which can be sufficiently violent

as to cause concern for the structural integrity of the aircraft, is most likely caused by disrupted airflow over the empennage. Disrupted air flow, in turn, usually results from some occurrence which disturbs the smooth outer shell of the aircraft, such as an object passing through the fuselage; an explosion in an engine nacelle, wing leading edge, or the fuselage; or an engine being wrenched from the aircraft. A fuselage explosion has been dicounted. Though not indicated factually or historically in any manner with respect to the propellers in use, failure of a propeller blade or portion thereof, or separation of an entire propeller by engine failure or nacelle explosion either from explosive fumes or turbosupercharger failure, are the most likely cause of the kind of damage being considered. These possibilities and their consequences are also suggestive of what may have happened to N 90944.

Lack of any known message from the aircraft after start of the emergency may be related to fuselage external and/or internal damage which broke antennas and/or caused major damage to the electrical distribution system. In view of conclusions elsewhere in the analysis, crew incapacitation is a definite possibility.

Since pathological study indicated the possibility of carbon monoxide in the cabin prior to impact, the most likely sources thereof must be considered. CO is generated in most any type of a fire (electrical, combustible fluids and solids) or by the thermal decomposition of many substances. A large fire within the fuselage is not compatible with the condition of the recovered wreckage so a smouldering fire would appear to be more likely. Such a fire would cause considerable smoke in the cabin, in addition to the carbon monoxide, and contribute to the off-course location of the crash but should have been controlled by the emergency fire fighting equipment carried on board unless the fire had ignited some material like nitrate film. Such a fire should not have created the need for an immediate ditching unless the smoke accompanying it was excessive and irritating and the fire was uncontrollable.

Component Failure

A more probable source of CO would be an unusual occurence in a power package which could have initiated a chain of events leading to the introduction of carbon monoxide into the fuselage. Such an unusual occurrence could be a failure which would release part of a propeller blade or the entire propeller, or a failed turbosupercharger disk. It is likely that such an occurrence would be accompanied by serious flight control problems and possibly fire. If a propelled object, such as a propeller, came through the fuselage it could easily start a fire, knock out some radio equipment, make emergency smoke evacuation procedures ineffective, and destroy the crew's emergency oxygen supply. Such an occurrence fits the known circumstances better than any of the other possibilities.

A third type of CO source which also fits most of the known circumstances is the malicious introduction of pure CO into the cabin and preferably the flight deck. CO unaccompanied by smoke would not be recognized by the crew and occupants and symptomatic quantities could be absorbed by the crew before they realized it. Under these circumstances complete incapacitation of the crew would result and the aircraft could have been flown into the water.

Several techniques have been used in the past to make quantitative determination of carbon monoxide in bodies of accident victims. Because of the violence associated with certain types of aircraft accidents the applicability of the results of some techniques and methods had been subject to question. The results were even more questionable when the bodies had passed through certain stages of putrefaction. Since the beginning of the Board's investigation of this accident the Armed Forces Institute of Pathology has devoted considerable time to verifying the suitability of the various testing methods available.

Further, and more important, a new technique was evolved which adapted the use of gas chromotography to the determination of carbon monoxide levels in the blood of accident victims. This new technique was demonstrated to be both specific and applicable for use on the bodies which were not exposed to advanced port-mortem decomposition.

In a recent Navy accident, which involved multiple casualties and similar exposure to warm sea water, two of the eight immediately lethal fatalities demonstrated elevated CO values. In that accident there was no inflight fire, but a post-impact surface fire did occur. This casts some doubt on the nearly established conclusion that carbon monoxide is not a byproduct of advanced stages of post-mortem decomposition. This question may take a considerable amount of time to resolve. The Board's report is being released, nevertheless, in the absence of a satisfactorily established cause.

The Board is deeply indebted to the Armed Forces Institute of Pathology for its valuable assistance in the investigation of this accident and its research which continues and has already made a significant contribution to the field of aviation medicine and airplane accident investigation.

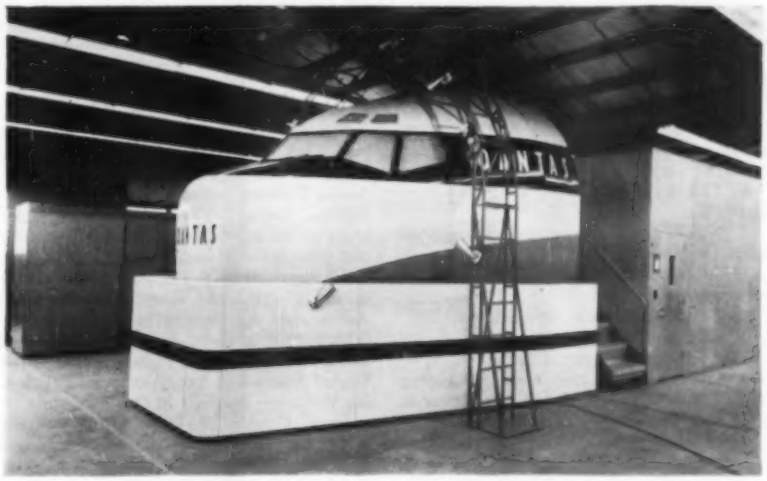
The maintenance history of 944, as obtained from the records, was, in the main, normal and there was nothing that could be related directly to the accident. However, in view of the incomplete hard-landing check at San Francisco, and the somewhat cursory check following the report of a "loud noise" in flight, also at San Francisco, maintenance and the airworthiness of the aircraft cannot be accepted as being normal in all respects.

Inspection Omission

The omission of the main spar inspection during the hard-landing check eliminated an important and what is probably the most onerous and time-consuming step of the procedure. This omission is considered to be significant and indicates that in this instance at least expediency rather than thoroughness prevailed. It can only be concluded that the "loud-noise" check was at best cursory. The Board's investigation of specific maintenance practices at San Francisco established these practices as not being entirely isolated cases.

However, the Board did find at the time of this investigation that the carrier was in the process of reviewing and, where necessary, revising their maintenance manual and procedures. This effort also included a realignment of some personnel assignments and responsibilities. Furthermore, the results of maintenance investigation were called to the attention of the CAA, by memorandum dated Mar. 19, 1958, with a recommendation that PAWA maintenance practices be reassessed. The CAA has advised that suitable corrective measures have been taken.

There was no evidence of a bomb-type explosion within the fuselage. Had a large-scale bomb explosion occurred in the fuselage (cabin, cockpit, baggage compartments,



Qantas Gets Boeing 707 Simulator

Boeing 707 simulator, built by Link Aviation Co., will be airlifted to Sydney, Australia, for use in Qantas Empire Airways jet transport crew training programs. Qantas simulator is first such training unit delivered by Link to a non-U. S. airline. Simulator will be flown to Sydney by two Qantas 1040H Lockheed Constellations and two Royal Australian Air Force Lockheed C-130 transports.

Fairchild Delivers F-27 to Bonanza

Fairchild F-27A turboprop transport, with Bonanza Air Lines markings, cruises over Hoover Dam en route to Bonanza's Las Vegas, Nev., headquarters. Airline plans to start F-27 service this month; six of the turboprop transports have been ordered.

and/or lounge), evidence of this would undoubtedly have been found on some of the recovered wreckage material as well as on the bodies.

FINDINGS

On the basis of all available evidence the Board finds that:

1. The crew, aircraft, and carrier were currently certificated.
2. The flight was properly planned and dispatched.
3. The gross weight of the aircraft at the time of takeoff was 147,000 lb., the maximum allowable.
4. Progress of the flight and position reports were normal and routine for more than half of the planned flight distance.
5. Shortly after the last routine report an emergency of undetermined nature occurred.
6. This was followed by a descent from 10,000 ft.
7. No emergency message was received from the aircraft.
8. Some preparation for ditching was accomplished.
9. The aircraft broke up on impact.
10. A surface fire then occurred.
11. Weather was not a factor.
12. Exposure of the crew to carbon monoxide was indicated but incapacitation could not be definitely established.
13. No evidence of foul play or sabotage was found.
14. Irregularities of maintenance practices and/or procedures disclosed during the investigation could not be linked to the accident.

The Board has insufficient tangible evidence at this time to determine the cause of the accident. Further research and investigation is in process concerning the significance of evidence of carbon monoxide in body tissue of the aircraft occupants.

By the Civil Aeronautics Board:

James R. Durfee
Chan Gurney
Harmar D. Denny
G. Joseph Minetti
Louis J. Hector

The Civil Aeronautics Board was notified of the unreported aircraft at approximately 0200, Nov. 9, 1957. An investigation was immediately initiated in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. A hearing, ordered by the Board, was held in San Francisco, California, on Jan. 15 and 16, 1958.

SUPPLEMENTAL DATA

Pan American World Airways, Inc., is a New York corporation with its main offices in New York. Headquarters for the Pacific-Alaska Division are at San Francisco International Airport. The corporation operates as an air carrier under a certificate of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Civil Aeronautics Administration. These certificates authorize the carrier to engage in air transportation between various points in the United States and foreign countries, including the route involved in this instance.

Capt. Gordon H. Brown, in command of Clipper 944, was 40 years of age and had been employed by Pan American since May 1, 1942. His record shows that he had been progressively advanced within the company and during his 15 years of experience he had made many over-ocean flights. Of his total flight time of 11,314:55 hr., he had accumulated 674:50 hr. in Boeing 377 aircraft. Capt. Brown was based at San Francisco and had been flying the Pan American Pacific-Alaska Division since Nov. 28, 1956. Company records show that all required airman certificates and ratings on the Boeing 377 were currently effective on the day of the accident. In addition, he had satisfactorily completed all PAWA ground training requirements, including periodic pilot refresher emergency equipment on the B-377 and wet-ditching drill on Aug. 2, 1957. He had had a rest period of approximately 11 days. Capt. Brown held a class one medical certificate dated May 1, 1957.

First Officer William P. Wygant was 37 years of age and had been employed by Pan American World Airways since Sept. 24, 1946. He had a total of 7,355:57 flying hours, of which 4,018:58 had been in B-377 aircraft. He was currently certificated by the CAA and had also completed all special courses including emergency equipment in the B-377 and the wet-drill for ditching.

Second Officer William H. Fortenberry, pilot-navigator for Clipper 944, had been employed by PAWA since August 27, 1951. He had a total of 2,683:10 hr., of which 1,552 were in the B-377. All of Mr. Fortenberry's certificates and ratings were currently effective and he had had a rest period of over 19 days prior to his departure on Nov. 8. Like both captain and first officer, he had satisfactorily completed all required regular and special courses, including emergency and ditching courses.

Flight Engineer Albert F. Pinataro, age 26, had been with PAWA since July 11, 1955. Prior to employment with the company he had completed an aircraft maintenance course (9 months) at Glendale, California, Junior College and an aircraft and engine course (9 months) at Los Angeles City Aircraft School. CAA certificates and ratings were currently effective and included those of flight engineer, aircraft and engine, aircraft and engine instruments, and radio telephone. His total flight time was 1,596:21 hr., all in Boeing 377 aircraft. Engineer Pinataro had 160 hr., rest period prior to his duty assignment on Clipper 944 on Nov. 8.

Cabin attendants assigned to the crew complement consisted of John E. King, Flight Service Supervisor; Oliver E. Crosthwaite, Purser; Marie L. McGrath and Yvonne L. Alexander, Stewardesses. All of these personnel had been employed by PAWA for several years and an examination of company records showed all of them had completed company training courses in B-377 emergency equipment and ditching procedures.

THE AIRCRAFT

N 90944, a Boeing model 377, serial number 15960, was owned and operated by Pan American World Airways and was currently certificated by the Civil Aeronautics Administration. The aircraft had accumulated 23,690:58 flying hours. It was equipped with four Pratt & Whitney R4360-B-6 engines. No. 1 engine had a total time of 13,804 hr., and 282 hr. since overhaul; No. 2 engine a total of 16,317 hr., and 1,208 hr. since overhaul; No. 3 engine a total of 16,961 hr., and 1,249 hr. since overhaul; and No. 4 engine a total of 13,459 hr., and 153 hr. since overhaul. The aircraft, engines, and propellers had been maintained as prescribed and were within their time limitations.

WHO'S WHERE

(Continued from page 15)

Changes

Dr. Konstantin Pestrecov, chief-optical systems group, Nortronics, a division of Northrop Corp., Anaheim, Calif. Also: **Walter Schumann,** applications engineer-automated checkout systems, and **Burl H. Ervin,** head-market research operations.

Fred E. Hamlin, manager of information services, Baltimore Division, The Martin Co., Baltimore, Md.

Charles R. Wood, Jr., manager-defense sales, Special Products Division, Weatherhead Aviation and Missile Group, Cleveland, Ohio.

W. W. Pierce, manager of the recently established support center-Atlas ICBM, Convair (Astronautics) Division of General Dynamics Corp., San Diego, Calif. Also: **J. M. Rogers,** superintendent; **K. R. Aiden,** acting chief-support supply; **L. I. Medlock,** chief-support quality control; **I. B. Jenkins,** chief-support manufacturing control.

M. Clayton Burgy, technical specialist, Hercules Power Co.'s new rocket propellant plant, Bacchus, Utah. **Clement J. Koeferl** succeeds Mr. Burgy as assistant manager of the explosives plant, Ishpeming, Mich.

Maj. Gen. Kingston E. Tibbetts (USAF, ret.), director, Pacific Division of the Denver Division, The Martin Co., Denver, Colo., Gen. Tibbets will direct the company's Titan ICBM activities at Vandenberg AFB.

R. E. Collier, customer relations representative-at-large, Electronics Division, Ryan Aeronautical Co., San Diego, Calif.

Raymond K. McClintock, manager of the new Mountain View Tube Plant of Special Tube Operations, Sylvania Electric Products, Inc., Mountain View, Calif. Also: **George Gunnell,** manager, production planning, Special Tube Operations; **William D. Tasker,** manager, Convair B-58 Hustler program office, Special Tube Operations.

G. M. Monroe, director, and **C. J. Benner,** assistant director, newly established business planning department, Chance Vought Aircraft, Inc., Dallas, Tex.

Norman R. Wild, chief engineer-equipment design, and **Thomas E. Woodruff,** chief engineer-preliminary design, Sanders Associates, Inc., Nashua, N. H.

William R. Baker, quality control manager, Montebello, Calif., plant of Western Design, a division of U. S. Industries, Inc., Los Angeles, Calif.

J. R. Strother, assistant manager-military gas turbine sales, Solar Aircraft Co., San Diego, Calif.

Eugene E. Elzufon, director of research, U. S. Flare Corporation and Associates, Saugus, Calif., subsidiary of Atlantic Research Corp., Alexandria, Va.

Victor K. Aubrey, site manager-San Diego, Calif., operation of Arma Division, American Bosch Arma Corp., Garden City, N. Y.

George J. Brown, chief engineer, Statham Instruments, Inc., Los Angeles, Calif.

William O. Packer, defense products representative-nuclear products, Erco Division, ACF Industries, Inc., New York, N. Y.

J. C. Nolan, operations manager, Stratoflex, Inc., Fort Worth, Tex.

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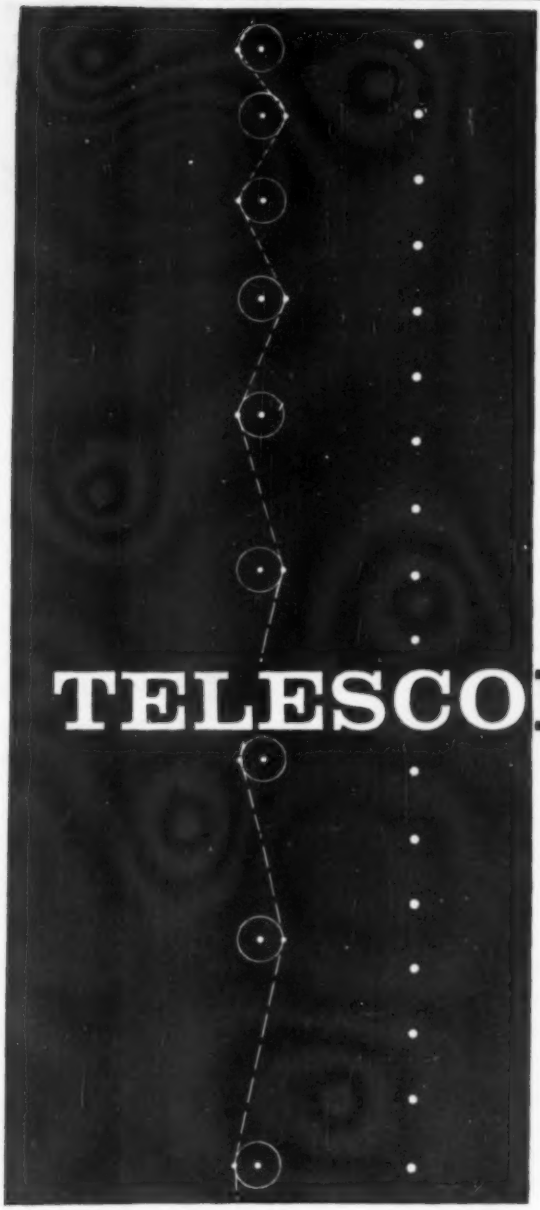

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LETTERS

Materials Dilemma

Re the Dec. 8 article, "Spacecraft Structural Factors Studied" (p. 55), some comments are in order. It is stated that the growth factor ". . . is about 44,000" for the fourth stage of an earth-Mars orbit vehicle. Assuming this is true (and every "spaceman" wants a high factor so cost can be said not to be a design consideration), then the two following statements are in conflict.

One conflict arises in the suggestion that a composite material, separating sealing functions from structural functions, should be developed. Quite obviously—and logically—this will cost more in weight. The structure plus the sealant represents the whole problem and must be accepted as such by the structures man. What good is an "efficient" structure which needs protection? Better to have less "efficiency" without sealant. The total weight—and that is really all that is important—may well be less. We have a similar situation now in motor design. We "save" structural weight like mad in the metal cases and then provide internal insulation so we can use high strength, brittle metals we probably wouldn't need if we put the insulation weight into the cases and operated at higher temperatures and lower stress levels.

The other conflict is the recommendation that we have exposure space stations so we can test materials under actual environments. Fine. But what do we use for materials in these high altitude stations while we are finding out what to use to build them?

Perhaps we'd better take a lot of small materials steps as rapidly as possible rather than trying the "giant stride" every time.

Charles F. Marschner
Los Altos, Calif.

Altimeter Design

Side-by-side pictures of the old and new style altimeters of the types concerned in the current New York accident investigation were published recently (AW Feb. 16, p. 37). Upon inspection of them, a number of ideas occurred to me which I thought might be of interest:

1. Possible proximate cause of the disaster.

The altimeter setting scales are on opposite sides of the instrument. Although clockwise rotation of the scale for decrease in pressure setting has been preserved, the effect of the scale relocation in terms of perception is one of radical change. For example, lower pressure settings are now at the bottom of the window, rather than at the top. The point is precisely this: in instrument design, although some elements of construction significant to perception can be retained in a change of physical configuration, all elements cannot. The mechanism of human perception is beyond the control of the designing engineer. Some elements of the perspective process may be common to large numbers of people, and may be understood, but much of the perceptive process is inevitably of a highly individual and hence of a highly variable nature. The additional element of the highly individual and variable nature of habit formation is significant also when a change of configuration is made. (Viz. Is the direction of rotation of the setting scale important in the formation of a habit, or is the bottom/top orientation of the figures? Would one be important to one individual, and the other to another? In this connection it would also be interesting to know the directions of rotation of the setting knobs.)

2. Construction of the instruments—The Presentation.

The drum and pointer presentation is undoubtedly simpler to understand and to learn to use than the triple pointer type. But is it really better? A clue to this question may be found in the fact that although drum indicating watches and clocks have been available for years, they have never been popular. The answer which suggests itself is startling in its simplicity: numbers, which are inevitably small and crowded, must be perceived and correctly read on a drum instrument. A pointer instrument ordinarily can be read to a fair degree of accuracy even if there are no numbers or calibrations at all. In terms of perception, pointer instruments have the vast advantage of the enormous angular and linear displacements involved in the analog nature of their presentation. Drum indicators are inherently a digital nature of presentation, whether or not they technically give an analog presentation.

Figures must be perceived and read, and no matter how large they may ordinarily be made they cannot, as a practical matter, subtend a visual angle comparable to those ordinarily found in a pointer presentation. Even if they could, the mechanism of digital perception would still depend on the smaller elements forming the structure of the digit.

The hundreds pointer on the new-style instrument has a long, slim section between the hub and the pointer arrow. It is obviously so designed in order that the pointer not eclipse the drum indicator as it moves between 100 and 400 ft. indications. The loss of pointer visibility, due to the slim section, may impair its usefulness as an indicator in an application where frequent reference to it is necessary, and where perception of it is primarily angular.

The figures on the circular scale of the new instrument, while large, do not seem to be of as easily legible a design as those on the old instrument.

The figures on the setting scale of the new altimeter appear to be inexcusably small.

3. A footnote on educational psychology.

It should be clear that the above arguments tend to support a thesis that that which is most easily taught, and most easily understood, may not necessarily be best. The mechanism of presentation and perception is such that complication in construction and the process of presentation may achieve objectives which are quite worthwhile in terms of safe and efficient use.

That such efficient use requires the acquisition and use of human skill should not deter the use of the more complicated presentation where its use is justified. After all, no one would really consider building a push-button violin just because it might be easier to play.

Stanley Harwich
Consulting Electronic Engineer
Brooklyn, N. Y.

Aviation Week welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to the Editor, Aviation Week, 330 W. 42nd St., New York 36, N. Y. Try to keep letters under 500 words and give a genuine identification. We will not print anonymous letters, but names of writers will be withheld on request.

Majority Rule

It is disheartening, to say the least, to read in your excellent magazine letters like Rule Enforcement (AW Jan. 19, p. 122), by H. B. Davis. The basic fact which he and all others crying for more rules, more rigid enforcement, or both, fail to see is easily discernible from the following figures taken from Aviation Week: USAF 1957, total aircraft—24,987; USN 1957, total aircraft—11,785; scheduled air carriers, total aircraft—776; civil aircraft, licensed—60,432 and unlicensed—24,888. By simple addition I arrive at the fact that while there are a total of 85,320 civil aircraft in 1957, there are only 37,548 military and air carrier planes. Since 1957 the number of civil aircraft has swelled tremendously, while the military and air carrier planes have about held their own. However, the majority shouldn't rule in all cases—only if they are right. I would only like to point out that the added work imposed by forcing the civilian pilots of the at least 60,432 aircraft to show proper credentials together with filling out the proper forms would tie up all major terminals to the point that they would be unable to even reach a "mike" let alone give any aid to inflight airplanes. As for policing the air with the few T-28s flyable. I can only say, why add to the confusion?

If any of you lightplane pilots reading this have been buzzed by a military jet and found the futility of getting the pilot grounded or reprimanded, I am sure that you felt just as I did when buzzed by a B-47 while flying a 1939 Aeronca Chief. Being off airways, out of control zones, and 600 ft. above the ground, I would gladly have used a shotgun had I had one. After all, we lightplane pilots help foot the bills for the military flyboys and should be shown common courtesy. Air courtesy being more important than air discipline to the lightplane pilot, then let us have the first 20,000 ft. in which to practice courtesy and let those who want discipline have the area above that. When we have to be controlled like the ICBMs I'll exchange my Chief for the nose cone of a rocket to the moon.

Only when civilization has reached the pinnacle of mentality where no pedestrian has an accident can anyone hope to keep the air accident free. Until that time don't strain your brain controlling us, stay above us. At airports let us have a piece of the ramp to set down on and we will quit fouling up our GCA and other government owned facilities designed for your use; after all, we civil aircraft are only in the majority by two to one.

R. W. Magers
Hiawatha, Kans.

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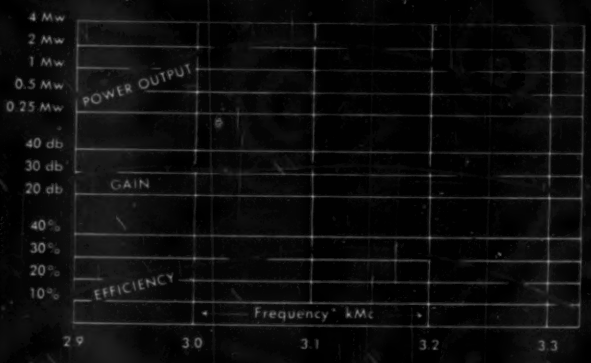

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